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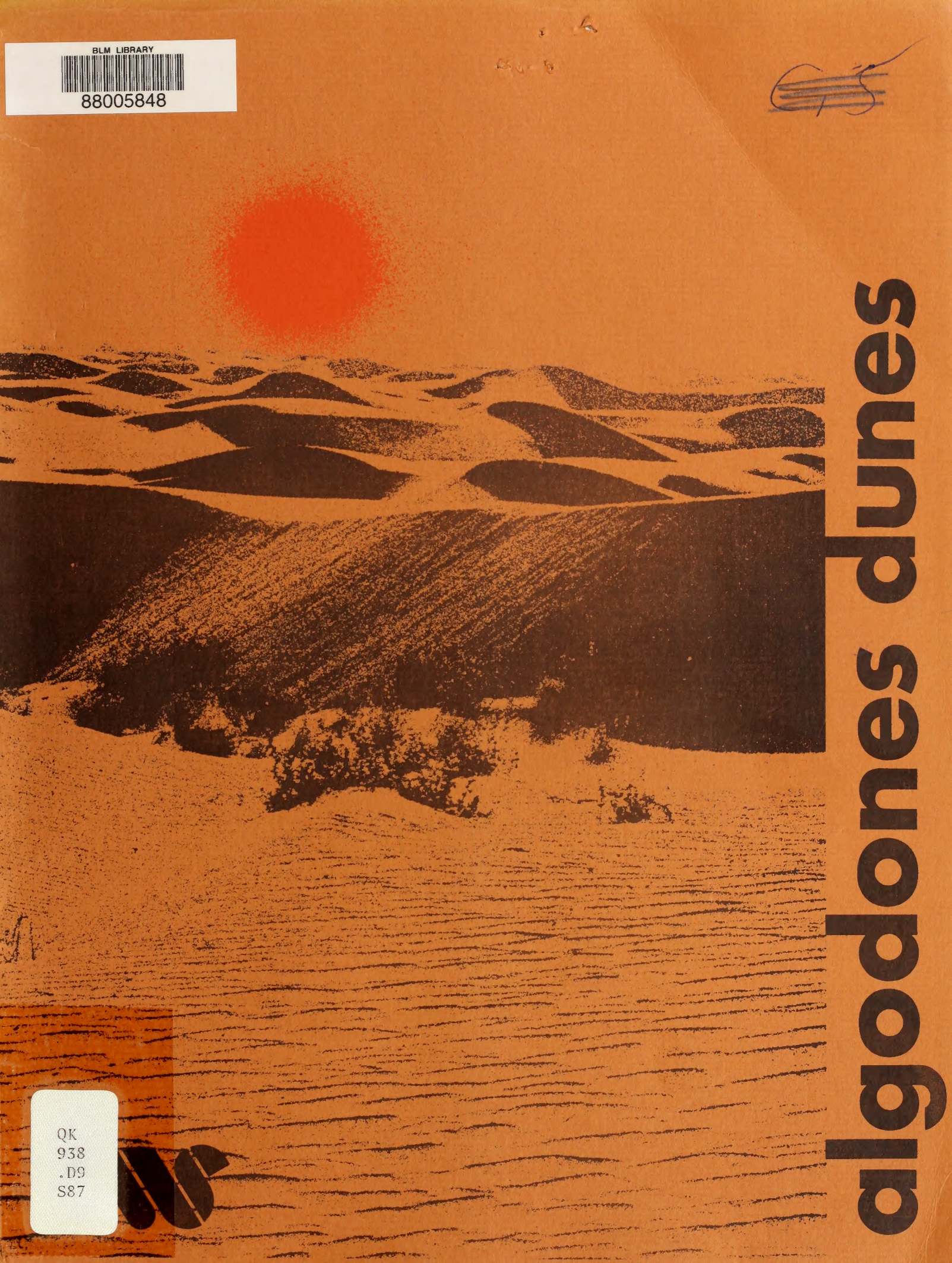

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SURVEY OF SENSITIVE PLANTS OF THE ALGODONES DUNES

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August 1977

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ABSTRACT

Vegetation in and around the Algodones Dunes, Imperial County, California, was surveyed both by ground and helicopter. Five vegetation associations were mapped within the Algodones Dunes, including Creosote Bush Scrub, Desert Microphyll Woodland, Desert Psammophytic Scrub, introduced vegetation along the Coachella Canal and Open sand areas. Seven sensitive plant taxa were surveyed. These taxa included the proposed endangered Ammobroma sonorae, Croton wigginsii, Helianthus niveus ssp. tephrodes, and Palafoxia arida var. gigantea as well as the proposed threatened Eriogonum deserticola. Astragalus lentiginosus var. borreganus and Astragalus magdalenae var. peirsonii, both listed as rare and endangered by the California Native Plant Society, were also surveyed.

All seven sensitive plant species were present in significant numbers within the dune system. The distribution and relative density of each were mapped. Along with discussion of habitats and known threats, observed impacts of ORV use are also discussed.

SECTION 1.0

INTRODUCTION

1.1 Scope of Work

This report summarizes the findings of an intensive literature and field survey of the vegetation of the Algodones Dunes (also called the Imperial Sand Hills) located in Imperial County, California. The survey was performed by WESTEC Services, Inc. under contract to the Department of Interior, Bureau of Land Management (Contract No. YA-512-CT7-133).

A management conflict currently exists at the Algodones Dunes relative to the areas and intensity of Off-Road Vehicle (ORV) use that should be allowed. Portions of the dunes which are popular ORV areas undergo intensive use during some periods of the year. The Bureau of Land Management has the responsibility of providing recreation opportunities for the public on its administered land including the Algodones Dunes. In addition, the Bureau of Land Management, as a Federal Agency, is required by the Endangered Species Act of 1973 to insure the conservation of endangered and threatened plant and animal species. This includes the commitment to formulate a screening program to insure that its actions do not jeopardize the existence of a species or adversely modify its Critical Habitat. Data gathered by this study are designed to provide specific information on which the

Bureau of Land Management can base future management decisions concerning the Algodones Dunes.

Three specific objectives for the study were identified by the Bureau of Land Management. These three objectives are to:

1. Determine the presence in the study area of any sensitive plant including threatened and/or endangered plants and other plants that appear in the investigator's opinion to be rare, unique and/or endemic.
2. Determine the environmental requirements of all plants identified in the above objective.
3. Provide specific data on the distribution, habitat requirements, relative population size, probable population trends and known threats to each plant species identified in the first objective.

The study included a literature and herbaria search on all identified sensitive species, an initial vegetation analysis through the use of aerial photographs, and a helicopter flyover. These initial surveys were followed by systematic ground surveys by qualified investigators.

1.2 Description and History of the Algodones Dunes

1.2.1 Location

The Algodones Dunes are located within the southeastern region of Imperial County, California. As shown in Figure 1-1, the dune system forms an approximately 40 mile long belt trending in a northwesterly direction and ranging from three to six miles wide. The extreme southern section of the dune system (approximately 1.5 miles) is south of the International Border in Mexico. The Southern Pacific Railroad forms a general eastern boundary with the Coachella Canal serving as a general western boundary of the Algodones Dunes. The junction of the Coachella Canal and Southern Pacific Railroad forms the approximate northern border and the Colorado River Delta (in Mexico) forms the southern boundary. Major physical features in the vicinity of the Algodones Dunes include the Imperial Valley to the west, Chocolate Mountains to the north and east, Cargo Muchacho Mountains to the east, and the Colorado River Delta to the south.

The Algodones Dunes are one of several dune systems in the southwestern United States and adjacent Mexico. The location of several of the more prominent dune systems are shown in Figure 1-2. Both the California Division of Mines (1952) and Miller (1957) describe the Algodones Dunes as the largest sand dune system in California and one of the largest

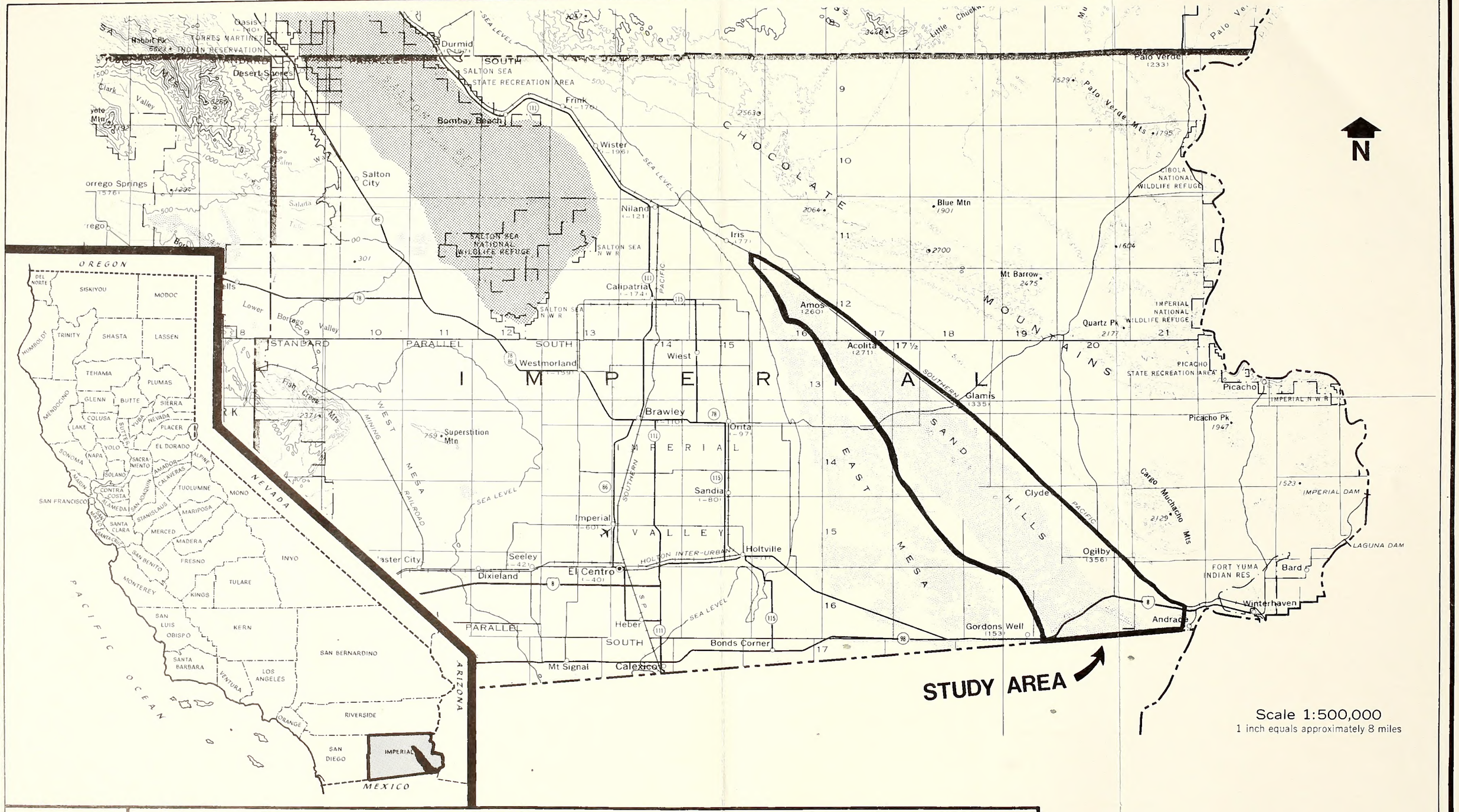

FIGURE 1-1

Vicinity Map

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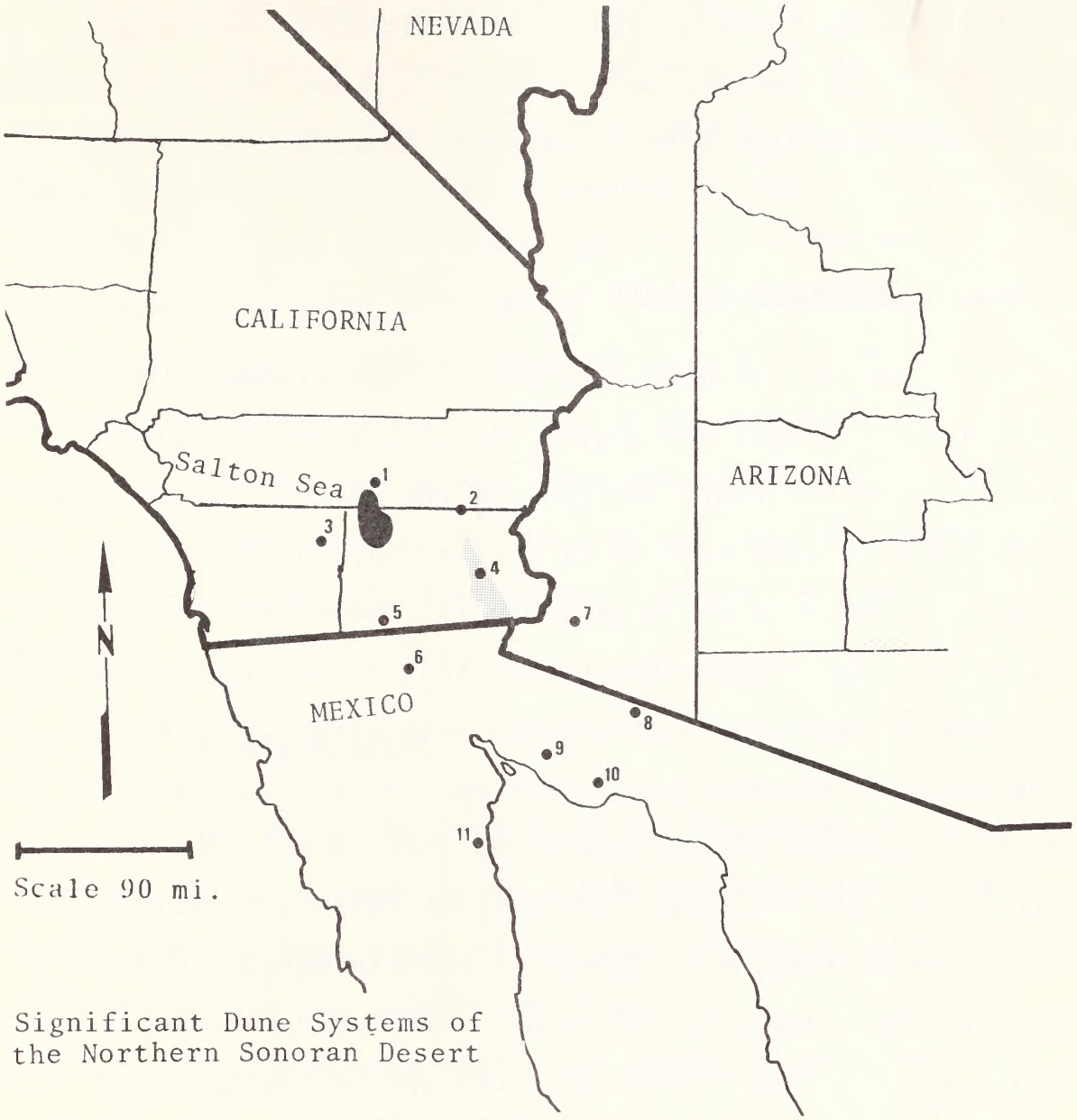


Significant Dune Systems of the Northern Sonoran Desert

1. Thousand Palms Dunes
2. Palen Dunes
3. Borrego Dunes
4. Algodones Dunes
5. Pinto Dune
6. Laguna Salada Dunes
7. Yuma Dunes
8. Gran Desierto Dunes
9. El Golfo Dunes
10. Bahia Adair Dunes
11. San Felipe Dunes

FIGURE 1-2 Significant Dune Systems

systems in the United States. In addition to the large expanse of the system, many individual dunes range between 200 - 300 feet high with a few major dunes exceeding 300 feet.

1.2.2 Geologic History

Major geological studies of the Algodones Dunes were done by Norris and Norris (1961) and Norris (1966). The dunes appear unsystematic from the ground, but as seen from the air, they consist of long north/south trending ridges on the west which individually curve as one moves eastward. The ridges then become indistinguishable in a complex of prominent south-facing slip faces along the extreme east boundary of the system. In the central and southern portion of the dune area, some of the slip faces are 200 to 300 feet high and overlook large flat-floored, sand-free depressions. Along the eastern margin of the dunes, particularly in the middle and southern parts, a sandy apron a mile or more in width extends out and away from the dunes and ends in a feathered edge against the alluvial fans extending from the Chocolate and Cargo Muchacho Mountains. The drainage channels from these mountains are intercepted by the dune system resulting in dense desert woodlands within lower areas of these feathered edges.

Norris and Norris (1961) conclude that the Algodones Dunes were probably produced by wind transport of sand from the beaches of Lake Cahuilla, a much larger forerunner of the Salton Sea. Apparently northwesterly sand-driving winds began to move sand inshore from Lake Cahuilla beaches immediately following development of the highest lake level. This sand quickly formed a chain of closely spaced dunes on the desert floor. Study of the dunes and morphology of the sand grains have indicated that the dunes are now less active than in the past and that the amount of sand is not increasing significantly (Norris and Norris, 1961).

1.2.3 Recent History

The first inhabitants of the Algodones Dunes area were members of a Yuman Tribe called the Algodones. The tribe lived on both sides of the dune system, frequently foraging within the dunes themselves.

The Algodones Dunes, not being suitable for agriculture, were of little economic interest to the early settlers of the Imperial Valley. In fact, the Algodones Dunes acted as a barrier to travel until construction of the plank road across the southern portion of the dunes in 1915 (Henderson, 1968).

Probably most notable in the recent history of the Algodones Dunes was the construction of the Southern Pacific

Railroad immediately to the east of the dunes and the Coachella and Highline Canals west of the dunes. Establishment of the Southern Pacific Railroad right of way initiated the establishment of small communities near the Algodones Dunes including the tiny settlements of Glamis and Amos. The construction of the Coachella and Highline Canals, major branches of the All-American Canal, precipitated the expansion of agriculture in the Imperial Valley to the west of the dunes. Although originally planned, agricultural development of the Pilot Knob Mesa east of the dunes has not yet occurred.

During the settlement of the Imperial Valley, most of the Algodones Dunes remained in the control of the Federal Government. The Algodones Dunes were virtually unused by the government prior to their designation along with East Mesa and the Chocolate Mountains as military bombing ranges. This use has continued within the Chocolate Mountains and East Mesa, but was discontinued within the Algodones Dunes.

By the 1950's, Imperial Valley residents were using stripped and cut-down automobiles with over-sized tires to drive through the lower sand dunes. The design of these sand or dune-adapted vehicles has progressed remarkably in the last twenty years so that sophisticated machines are now able to climb the steepest dunes. Off-Road Vehicle use within the Algodones Dunes and in other desert and coastal dunes has gained tremendous popularity within the last ten years. Bureau of Land Management officials have

estimated that 10,000 to 15,000 people used the Algodones Dunes during major holiday weekends. Principal areas of intensive ORV use are shown in Figure 1-3. These areas were established through observation by the study team of areas containing compacted sand and/or concentrations of tire tracks. The intensive use areas include the Competition Hill/Osborne Park/Gecko Campground area immediately south of Highway 78, the Buttercup Valley area immediately south of Interstate 8, and the Mammoth Wash area at the northern tip of the dunes.

Prior to the increase of ORV use, scientists began to recognize the biological uniqueness of the Algodones Dunes system (Weeks, 1929). A high vertebrate species diversity was identified in the dune area by Hill (1965), Mayhew (1962 and 1964) and other investigators. Several endemic insects species have been identified in the dune area by Irwin (1971), Hardy (1971) and other investigators. In addition, several plant species were identified as endemic to the region near and including the Algodones Dunes (Weeks, 1929). The United States Fish and Wildlife Service (Schreimer, 1975; and Greenwalt, 1976) identified four proposed endangered and one proposed threatened plant species as occurring in the Algodones Dunes. Those species were:

Ammobroma sonorae (proposed endangered)

Croton wigginsii (proposed endangered)

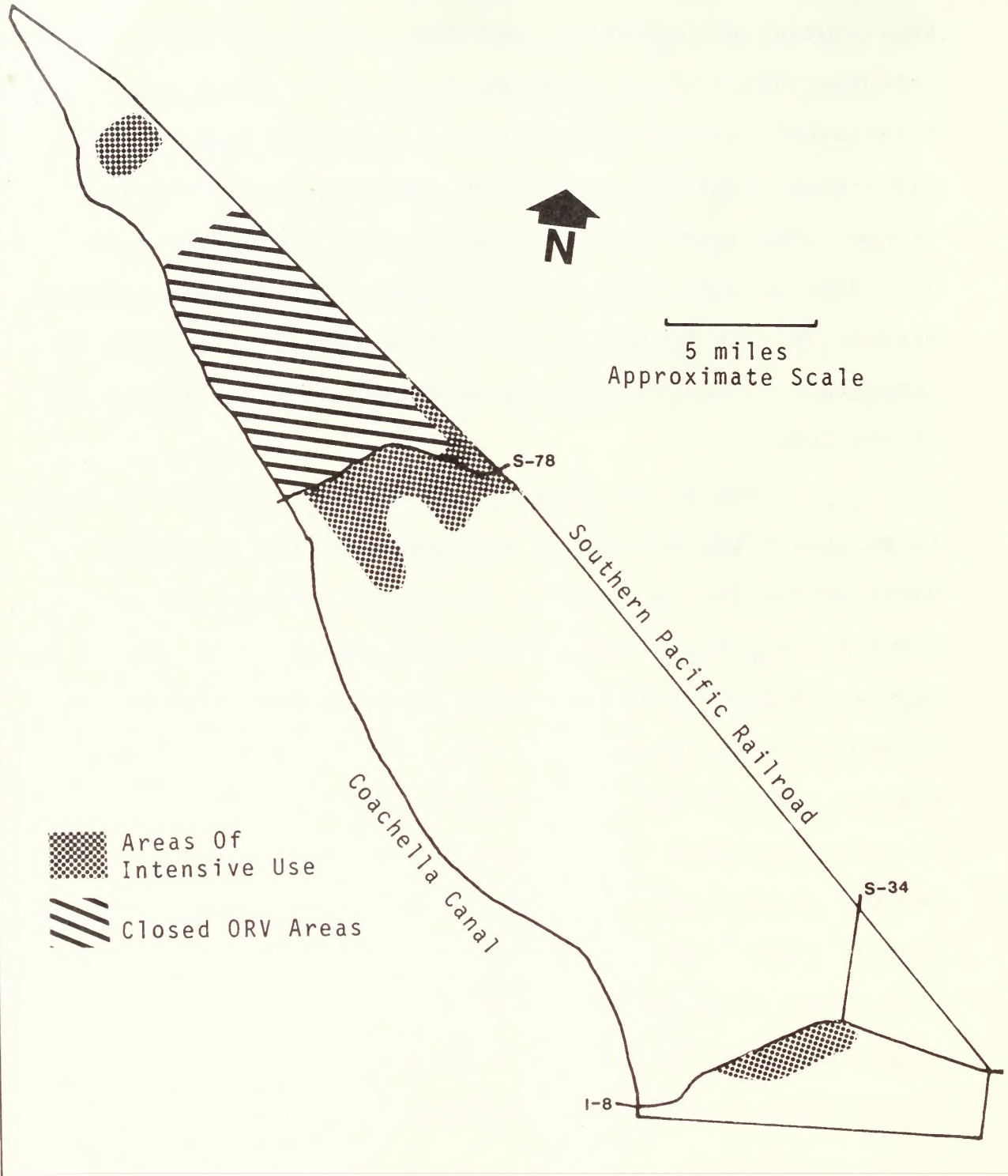


FIGURE 1-3 ORV Use areas

Helianthus niveus ssp. tephrodes (proposed endangered)

Palafoxia arida var. gigantea (proposed endangered)

Eriogonum deserticola (proposed threatened)

The California Native Plant Society (Powell, 1974) listed three additional rare and endangered plants that may occur within the Algodones Dunes. These species were:

Astragalus lentiginosus var. borreganus

Astragalus magdalenae var. peirsonii

Pilostyles thurberi

Plant taxa that have been considered Endangered, Threatened and/or Rare by the United States Fish and Wildlife Service and/or the California Native Plant Society are generally of limited distribution, and are restricted to specific microhabitats within their ranges. Many of the microhabitats of these plant taxa have been altered by man. It should be noted that these sensitive plant species may occur in high densities within their microhabitats.

In recent years, it became apparent that some protective measures to preserve the unique dune ecosystem were required. In 1966 the National Park Service declared the area eligible as a National Natural Landmark and in 1968 the Bureau of Land Management agreed to have the area listed as a Registered National Natural Landmark. Verity (1972)

proposed to the Bureau of Land Management that the dune area north of Highway 78 be established as the Algodones Dunes Research Natural Area. Although the research natural area was never established, the Bureau of Land Management did close a portion of the area north of Highway 78 to ORV use as shown in Figure 1-3. An ORV corridor from Highway 78 to the Mammoth Wash area was retained to allow easy access for ORV's to the Mammoth Wash area. This corridor was closed by the Bureau of Land Management early in 1977.

1.3 Description of Plant Species Investigated

The five plant taxa proposed as threatened or endangered by the United States Fish and Wildlife Service along with the three additional species identified as rare and endangered by the California Native Plant Society were considered sensitive plant species for the purpose of the study. A brief description of the eight species follows:

1.3.1 Ammobroma sonorae (Proposed Endangered)

Ammobroma sonorae, commonly known as "sand food" due to its apparent widespread use as a food source by local Indians, is a root parasite apparently using several perennial shrubs as host plants. The known range of this species is shown in Figure 1-4. Colonel A.B. Gray discovered Ammobroma in 1854 while engaged on a transcontinental railroad survey (Thackery, 1953). This species was described by Torrey (Gray, 1854) from A.B. Gray's collection at Adair Bay, Sonora. Based on known collections, the species occurs in the West Mesa and East Mesa-Sand Hills area of Imperial County southeastward into northeast Baja California and Northwest Sonora. The other species in the genus, A. culiacan, occurs further south down the Pacific coast off mainland Mexico (Dressler & Kuijt, 1968). Apparently the distinction between Ammobroma and the other genera of the Lennoaceae is not clear and a more critical look at the members of this rarely encountered family is in order (Kuijt, 1969; Drugg, 1962).

1.3.2 Astragalus lentiginosus var. borreganus (Rare and Endangered - California Native Plant Society)

This variety is part of the huge Astragalus lentiginosus complex of the western United States. The taxon was originally described by Jones (1898) from collections of T.S. Brandegee at Borrego Springs. Several other

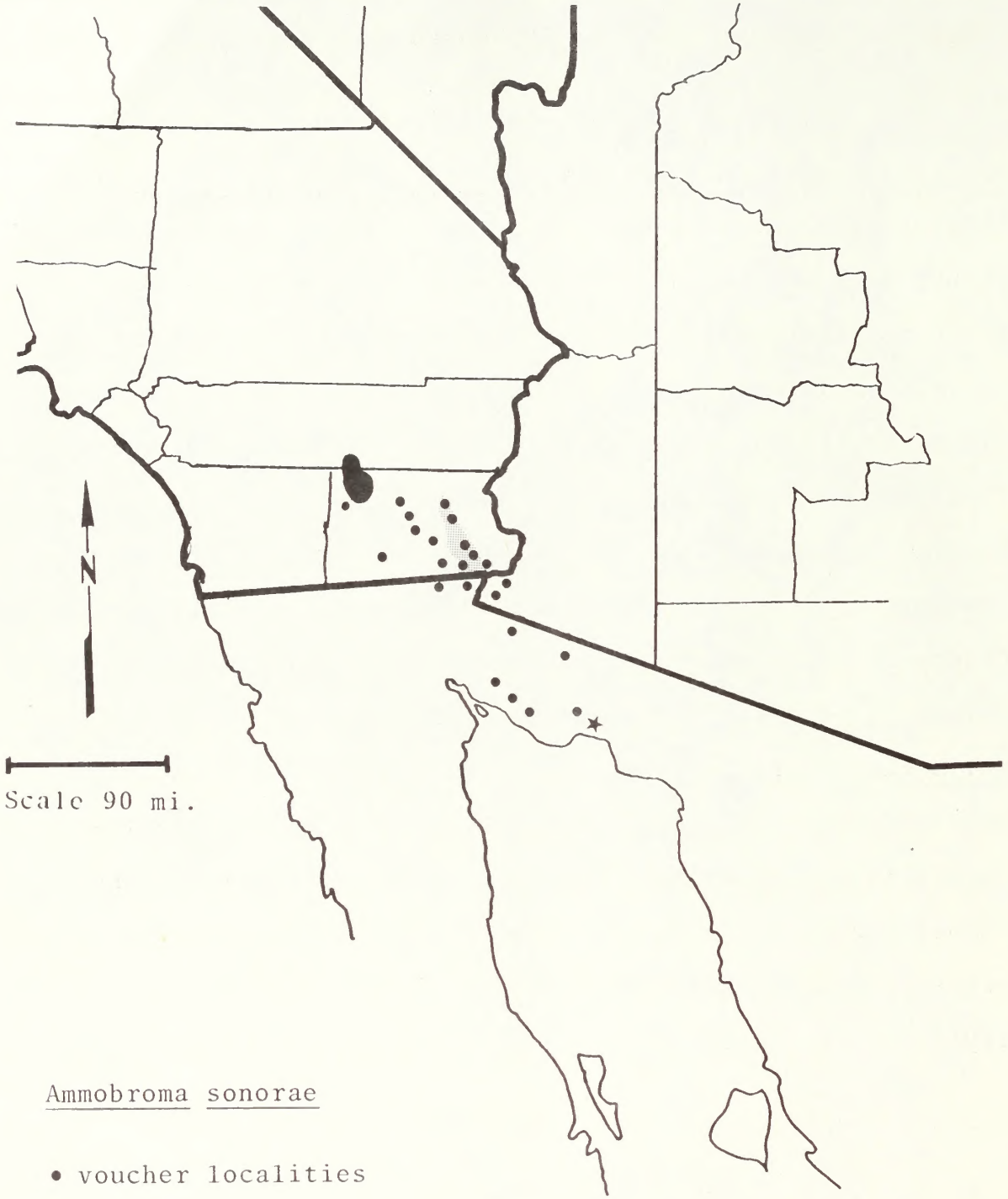


FIGURE 1-4 Distribution of Ammobroma sonorae

epithets have been placed in synonomy with A. l. borreganus. They are A. coulteri, A. Arthu-Schottii, and A. aginus. The taxon has two centers of distribution; the central Mojave Desert and Colorado Desert, suggesting two races of the taxon (Barneby, 1964). The known range of this species is shown in Figure 1-5.

1.3.3 Astragalus magdalenae var. peirsonii (Rare and Endangered - California Native Plant Society)

This very distinctive milk vetch was described by Munz and McBurney (1932) from a collection in the sand dunes between Holtville and Yuma. M.E. Jones dismissed the name as superfluous, the taxon being easily accommodated by A. lentiginosus var. coulteri (Jones, 1933). Barneby (1944) lumped the taxon with A. niveus but later proposed the combination A. magdalenae var. peirsonii (Barneby, 1958). The distribution of this species is shown in Figure 1-6.

1.3.4 Croton wigginsii (Proposed Endangered)

This species was originally described by Rose & Standley in 1912 as Croton arenicola from a collection by Mr. G. Sykes at Adair Bay, northwest Sonora, Mexico in 1908. The name was, however, preoccupied by a taxon in the southeast United States (Small, 1905). A new name for the taxon, C. wigginsii, was later proposed by Wheeler in 1939. The species was described by Shreve and Wiggins (1964) as occurring in sand dunes and along sandy arroyos ranging from southeastern

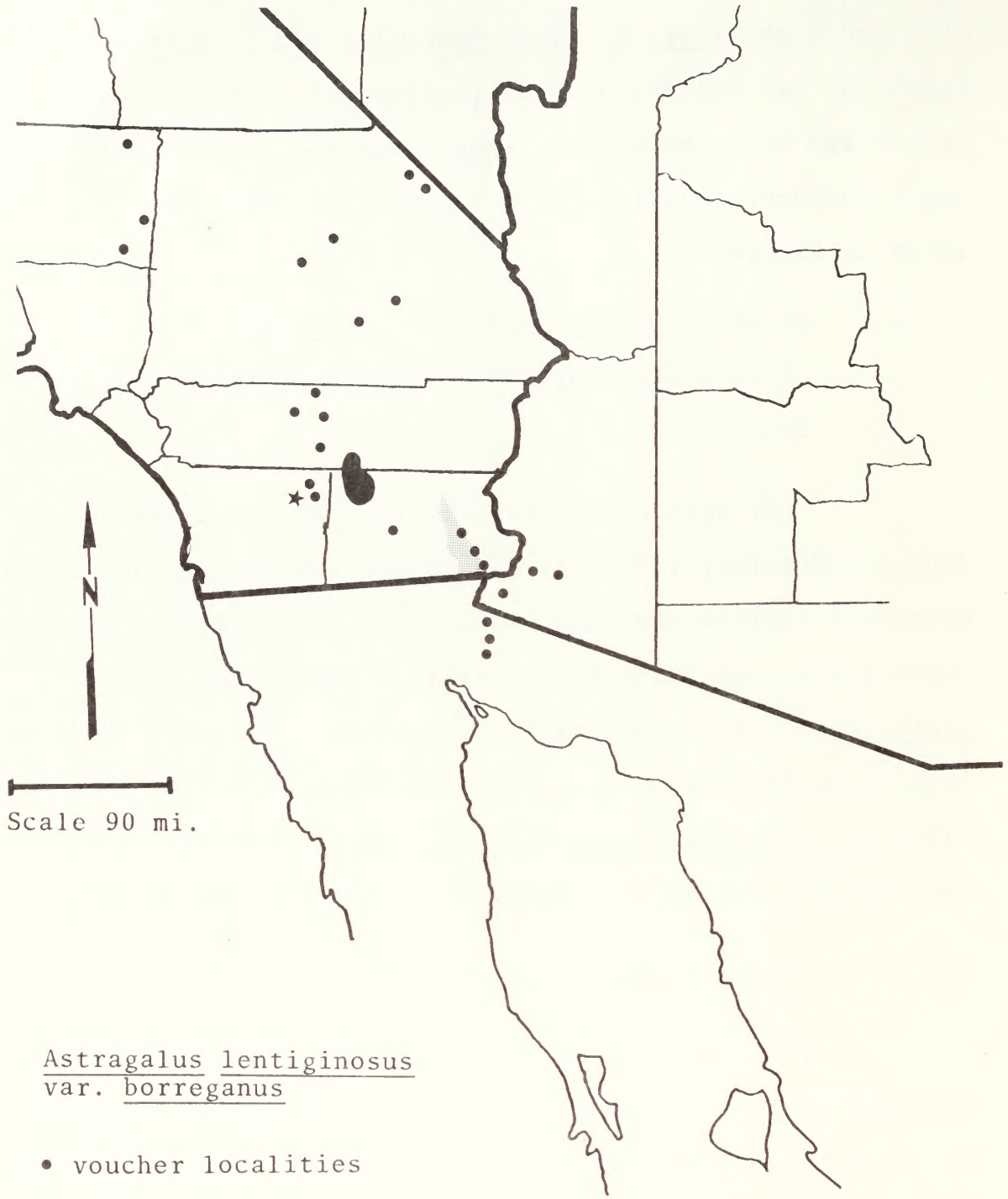


FIGURE 1-5

Distribution of Astragalus lentiginosus var. borreganus

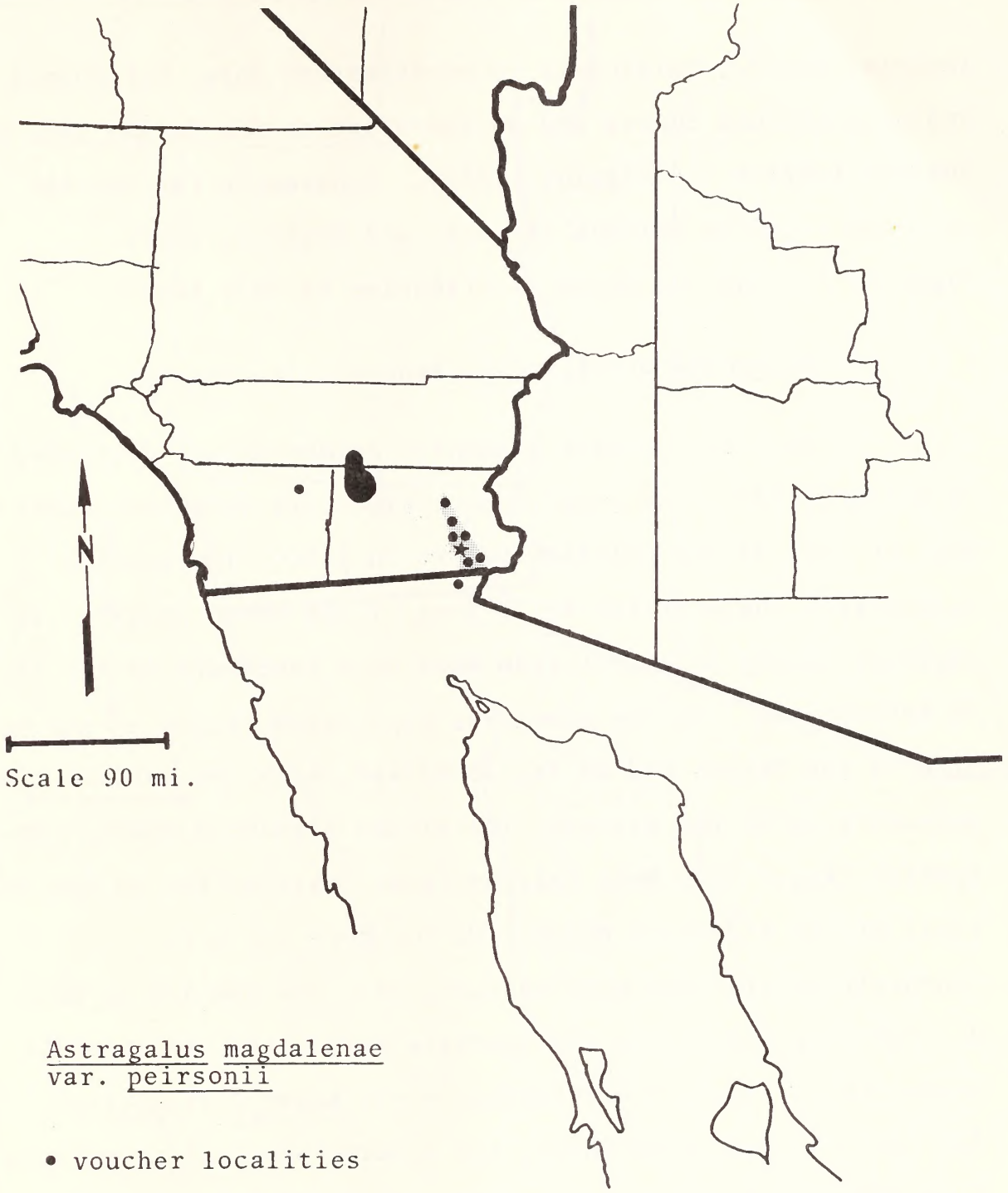


FIGURE 1-6

Distribution of Astragalus magdalenae var. peirsonii

Imperial County, California to northeastern Baja, California and northwestern Sonora and as far south as San Carlos Bay, near Guaymas (Shreve and Wiggins, 1964). Apparently the species does not occur in Arizona (Kearney and Peebles, 1960). Figure 1-7 shows the known distribution of this taxa.

1.3.5 Eriogonum deserticola (Proposed Threatened)

This distinctive perennial Eriogonum was described by Watson (1891) from a collection by Orcutt from the southwestern part of the Colorado Desert in 1890. The species ranges from the Ocotillo Wells area of San Diego County. In Imperial County it occurs from West Mesa southward to the vicinity of Westmorland. To the east, the population ranges up the east side of the Salton Sea as far as Niland, with the eastern limit appearing to be the eastern side of the Algodones Dunes. The species ranges into Baja California at least as far as the southern limit of the Algodones Dunes. No vouchers for more southerly populations were encountered. The species is best described as endemic to the southern portion of the Imperial Depression. Figure 1-8 illustrates the known distribution for the species. Apparently, the species was lost to science from 1891 until 1927, when it was rediscovered by W.L. Jepson (1929). A study of the plant's ecology was then made for Dr. Jepson by an Imperial Valley resident, I.T. Weeks (1929).

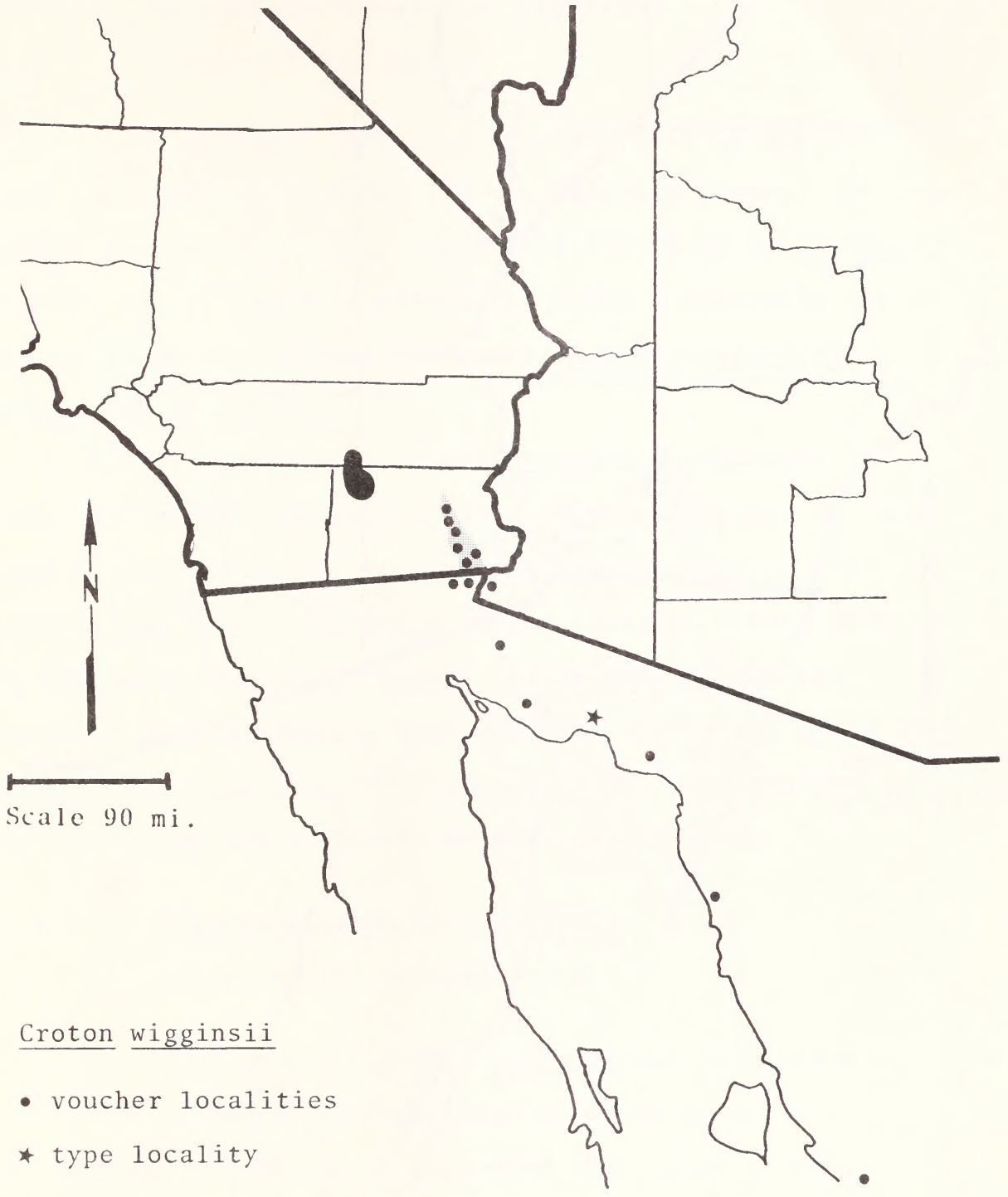
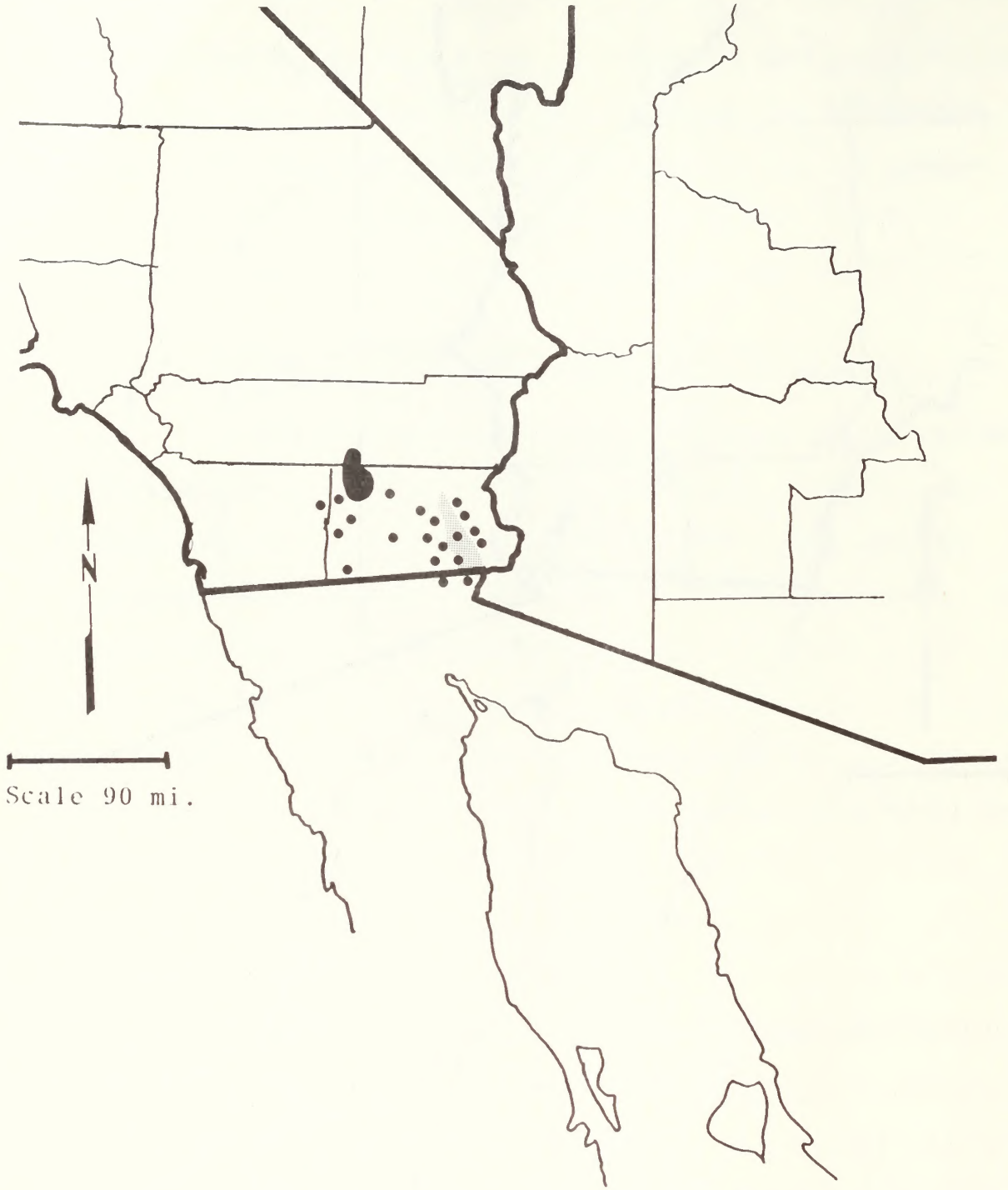


FIGURE 1-7 Distribution of Croton wigginsii



Eriogonum deserticola

• voucher localities

FIGURE 1-8 Distribution of Eriogonum deserticola

1.3.6 Helianthus niveus ssp. tephrodes

(Proposed Endangered)

Helianthus tephrodes was described by Asa Gray from a collection by Schott in the Colorado Desert. Heiser (1955) lowered the taxon to varietal status in H. niveus. Heiser, et al. (1969) assigned the taxon subspecific status and included in synonomy the names Viguiera tephrodes, V. nivea, and V. sonorae.

The subspecies is restricted to sand hills in Imperial County, California, Yuma County, Arizona, northeast Baja California Norte, and western Sonora. Figure 1-9 illustrates the distribution of the species. Other members of the genus include H. niveus ssp. niveus of coastal northern Baja California Norte and the widespread Helianthus niveus ssp. canescens, distributed in the southwestern United States and northwest Mexican desert areas.

1.3.7 Palafoxia arida var. gigantea

(Proposed Endangered)

Palafoxia arida var. gigantea was originally described by Marcus E. Jones from material he collected in the Algodones Dunes on 26 September 1931 (Jones, 1933). Aven Nelson, evidently unaware of Jones' earlier varietal epithet, proposed the name P. linearis var. arenicola (Nelson, 1936). Apparently Dr. Munz also had a name chosen for the taxon, since the name P. craigii appeared at Rancho Santa Ana

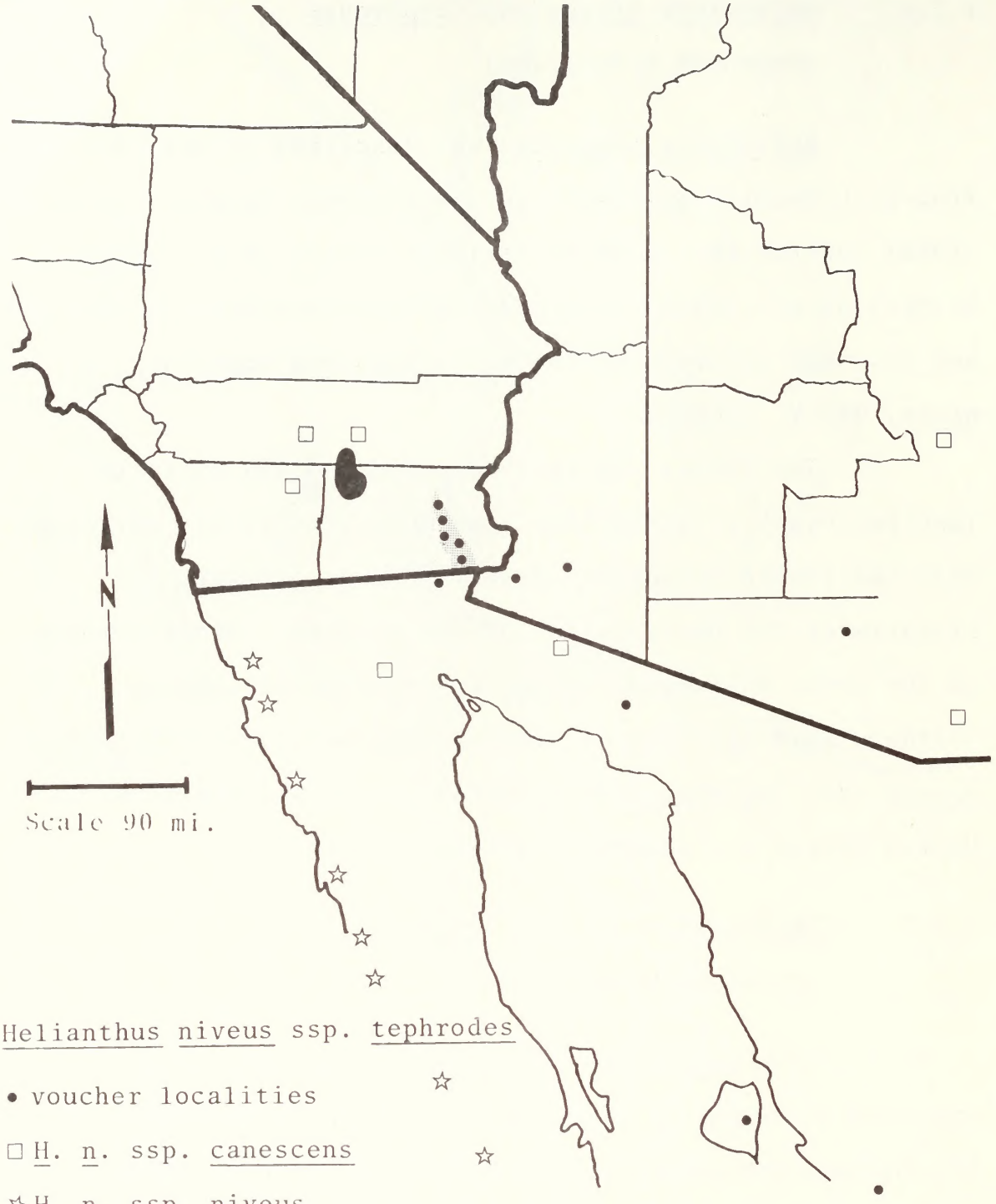


FIGURE 1-9

Distribution of Helianthus niveus ssp. tephrodes

Botanic Garden Herbarium on a 1932 collection for the Algodones Dunes. The name, however, was never formally published. Dr. B.L. Turner and his student, M.I. Morris have recently transferred the variety to Palafoxia arida (Turner and Morris, 1975). Palafoxia arida var. gigantea is restricted to the Algodones Dune system of southeast Imperial County and northeast Baja California Norte. The known range of this species is shown in Figure 1-10. The reason for Palafoxia arida var. gigantea being larger than the typical Palafoxia arida var. arida is not known.

1.3.8 Pilostyles thurberi

(Rare and Endangered - California Native Plant Society)

This parasite was described by Asa Gray (1854) from a collection by Thurber while involved in the Mexican Boundary Survey. The plant is parasitic on Dalea emoryi in the Colorado Desert and on D. formosa and D. frutescens further east. Rutherford (1970) and Kuijt (1969) have considered anatomical and morphological aspects of this species. The distribution of this species is shown in Figure 1-11. It was not found during the survey, although its host, D. emoryi was frequent in Creosote Bush Scrub.

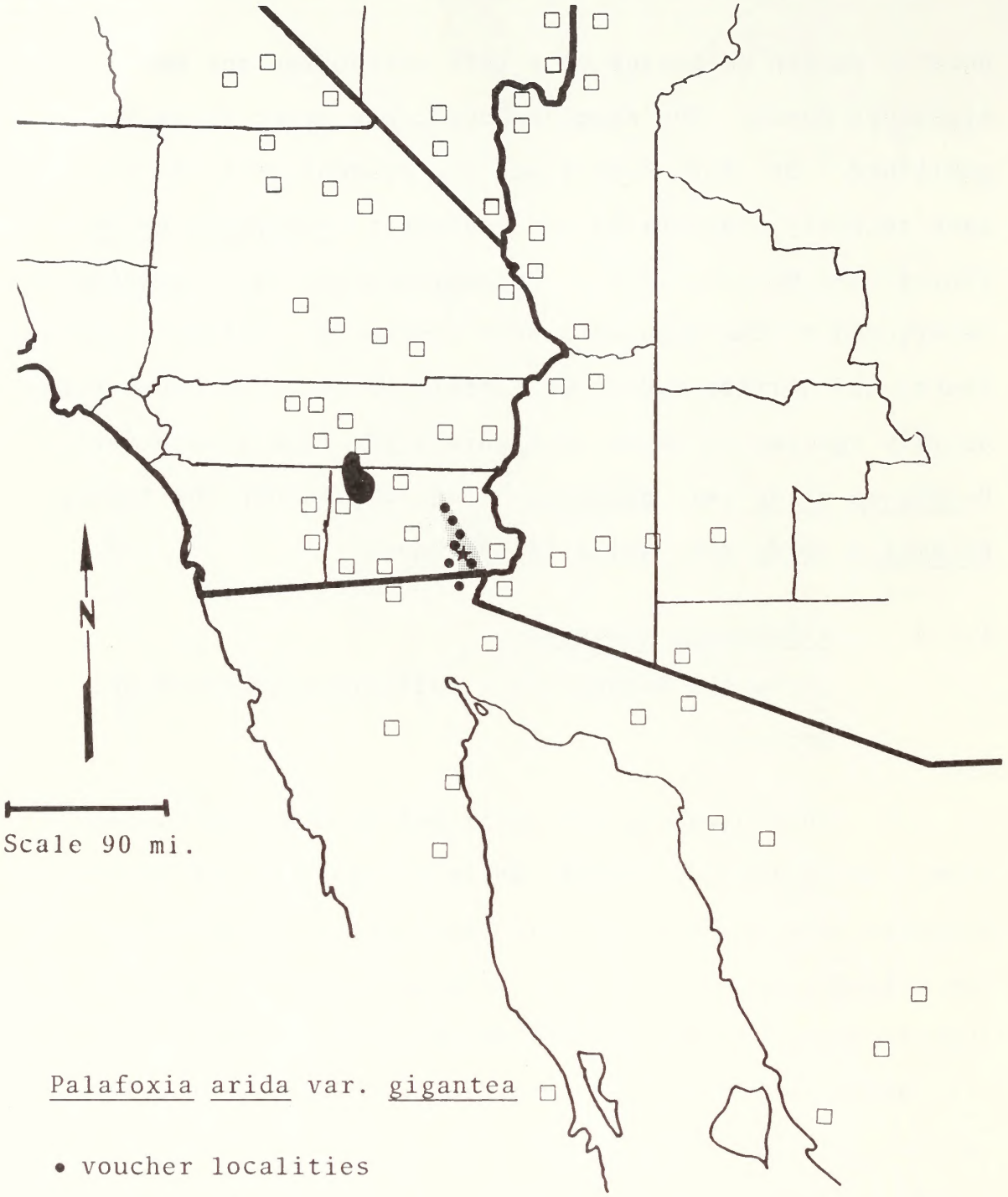


FIGURE 1-10 Distribution of Palafoxia arida

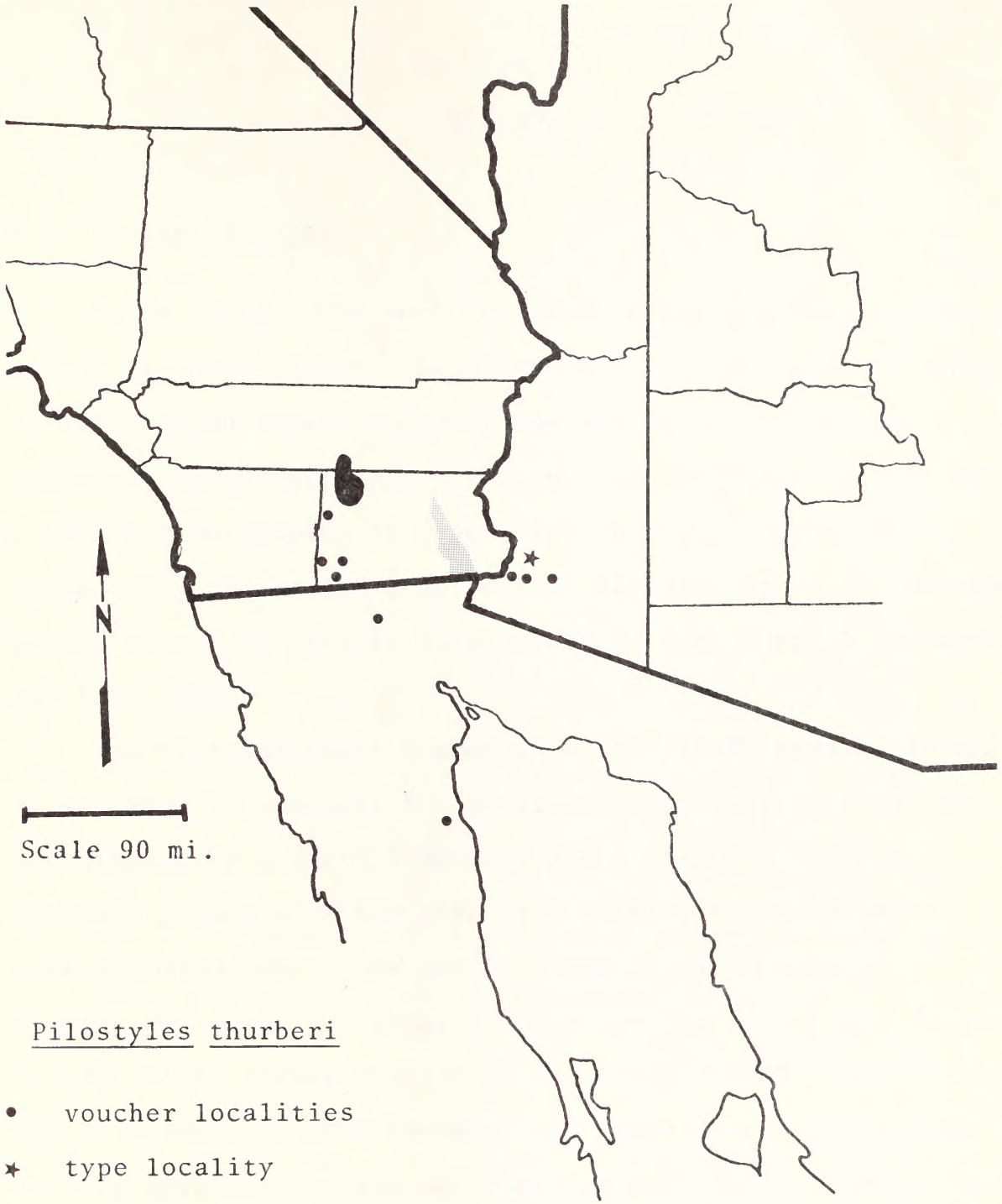
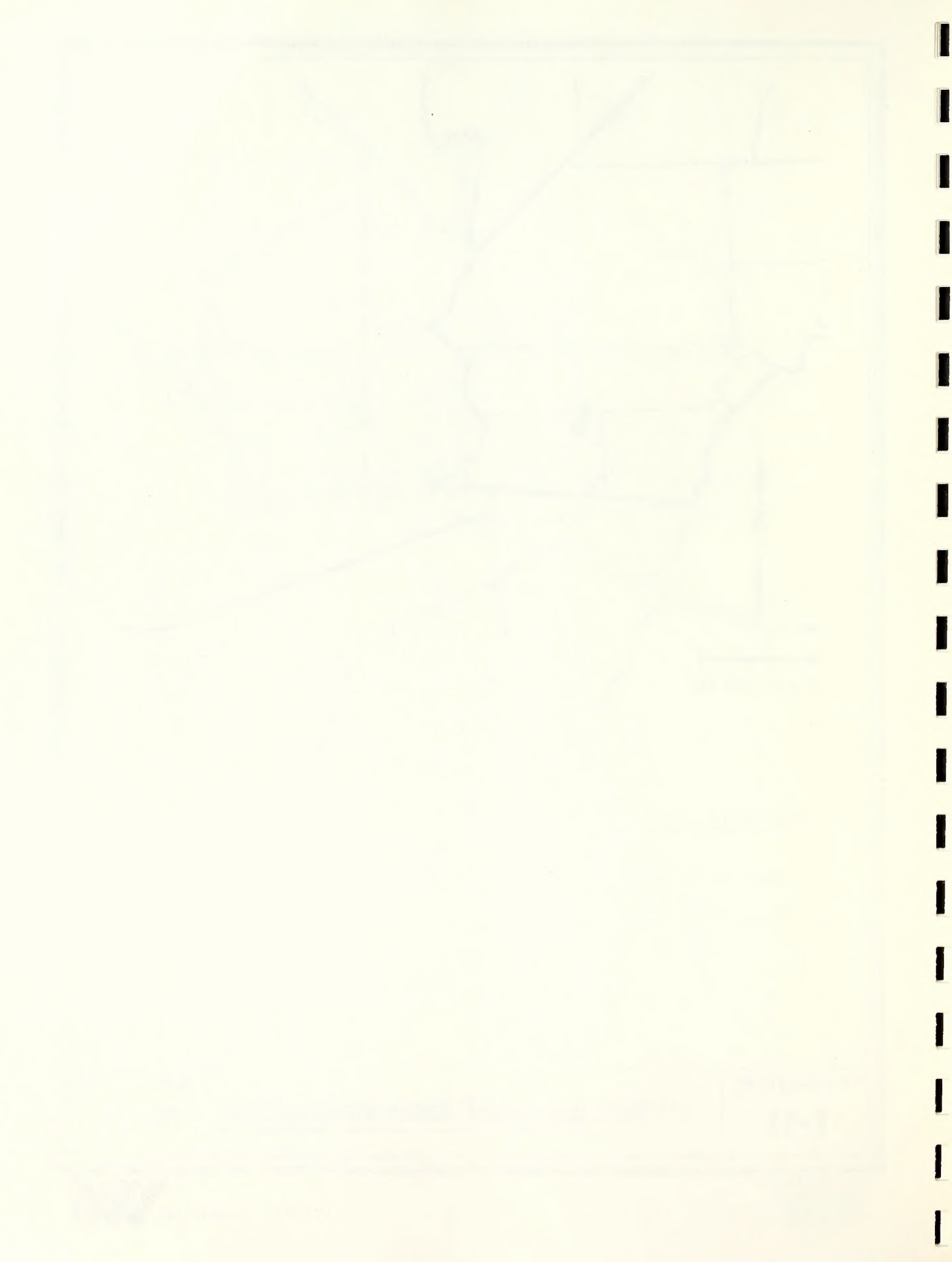


FIGURE 1-11 Distribution of Pilostyles thurberi



SECTION 2.0

METHODS

2.1 General Approach

Three basic steps were followed in the vegetation study of the Algodones Dunes. These were: 1) accumulation of known information on sensitive plant species occurring in the Algodones Dunes through a literature and herbaria search, 2) a generalized mapping of vegetation through analysis of aerial photographs and a helicopter flyover, and 3) a thorough ground survey by staging field crews in dune-adapted vehicles and helicopter.

The organizational framework of the study team personnel is outlined in Appendix A. Basically, the overall study was coordinated by a project manager and a senior scientist. Separate groups were assigned specifically to the literature/herbaria search and to the formulation of a grid mapping system of the dunes. Three two-man teams were formed for the field survey portion of the study. Each field team was directed by a Team Leader. Team Leaders were biologists holding advanced degrees and familiar with desert vegetation. Other team members were trained biologists experienced in vegetation analysis.

2.2 Literature/Herbaria Search

The survey for literature relevant to the study was made at several subject levels. The major topics surveyed included the general topic of sand dunes as well as a review of the various plant taxa involved. A survey of recent ORV related literature was also made.

The initial data search of the general subject of sand dunes was accomplished through a computer data retrieval system operated by the Western Research Application Center of the University of Southern California. Data bases searched included "Biosis", "Sci Search", Chemical Abstracts, "Enviroline", "Datrix", "Agricola", "NTIS", Dissertation Abstracts, and Engineering Index.

Most information concerning plant taxa was obtained from monographic works of various ages and completeness. In addition, biological abstracts and other indexes were searched. As the subject of ORV impacts is relatively new, the literature survey for that subject was accomplished by compilation of published and yet to be published research papers.

The herbaria search was accomplished by correspondence and in person. A listing of herbaria searched is included in Table 2-1. In addition to the herbaria search, primary data sources used in the California Native Plant Society's Inventory of Rare and Endangered Plants of California were

TABLE 2-1

HERBARIA SEARCHED

CODE	
ASU*	Arizona State University Herbarium Tempe, Arizona
GH*	Gray Herbarium of Harvard University Cambridge, Massachusetts
US*	U.S. National Herbarium, Smithsonian Institute Washington, D.C.
NY*	The New York Botanical Garden Bronx, New York
MO*	Missouri Botanical Garden St. Louis, Missouri
RSA-POM*+	Rancho Santa Ana Botanical Garden Pomona College Herbarium Claremont, California
JEPS-UC*	Jepson and University of California, Berkley Herbarium Berkley, California
SD+	San Diego Museum of Natural History San Diego, California
SDSU+	San Diego State University San Diego, California
MACF+	MacFadden Herbarium California State University Fullerton, California

* Herbarium contacted by correspondence.

\+ Herbarium visited by a member of the research team.

available to the study team. Finally, lists of exsiccatae were obtained from some monographers.

2.3 Initial Vegetation Mapping

Subsequent to initiation of the literature/herbaria search, a preliminary vegetation study of the dune system was made through the use of infrared aerial photographs and a helicopter flyover. The preliminary vegetation study was undertaken to acquaint team leaders with the physical and biological features of the dune system as well as to map vegetation associations and vegetation densities on a tentative basis. This preliminary vegetation study also provided the basis for determination of the boundaries of the field investigation and for ascertaining the intensity of field survey needed in each vegetation association.

Color infrared aerial photograph transparencies taken by a U-2 aircraft at an approximate scale of 1:126,000 were examined through the use of a light table and stereo-pair viewers. Black and white negatives were made from the color positives, and enlarged black and white prints at an approximate scale of 1:28,000 were made. Major vegetation concentrations most notably Desert Microphyll Woodland and Creosote Bush Scrub, (Thorne 1976) were mapped by this method. Additionally, physical features including roadways, canals, and campgrounds were mapped.

Flyover of the dune system was made by study leaders in a four-passenger Bell Jet Ranger II helicopter. During the one-day flyover, a generalized systematic search of the dunes was accomplished. Frequent stops were made by the helicopter to allow team members to investigate areas of interest and to allow placement of marker stakes with flags on several high central dune peaks. These marker stakes were used as navigational aids during the field survey stage of the study.

2.4 Formulation of Grid System

From the outset of the study, it was apparent that a systematic search of the entire dune system was required to adequately assess the flora and vegetation. This decision was based on distribution patterns of the monitored plant species. A grid system was formulated to assure a systematic search pattern (Figure 2-1).

The Coachella Canal and the Southern Pacific Railroad served as the study area's western and eastern boundaries respectively. The intersection of the Canal and railroad served as the northern boundary and the International Boundary served as the southern boundary. All sand dune areas of the Algodones Dune system (within the United States) as well as good representative areas of Creosote Bush Scrub and most Desert Microphyll Woodlands are contained within these boundaries.

As shown in Figure 2-1, a grid system or mosaic with each quadrant approximately 0.45 mile on a side was formulated for the primary study area. The grid system was based on the California Coordinate System with grid lines aligned due east, west, north, and south. Each quadrant was identified by its north/south and east/west coordinate number. A 0-0 point was arbitrarily made at Glamis near the junction of Highway 78 and the Southern Pacific Railroad. Grids were numbered consecutively in all directions from the 0-0 point as shown in Figure 2-1. The grid system was laid out on 7.5 minute United States Geological Survey (USGS) topographic maps. In some portions of the study area where 7.5 minute USGS topographic maps were unavailable, 15 minute USGS topographic maps were photoenlarged to approximate the scale of the 7.5 minute maps.

The midpoint of each east-west grid row was marked by stakes and sign posts along the railroad, Coachella Canal, and Gecko Campground Road. These markers were used as navigational aids for helicopter and ground survey crews.

2.5 Field Survey Methods

The field survey portion of the study was accomplished between June 3 and June 29, 1977, with the major portion of the field survey taking place between June 13 and June 29. Due to the time of year, the study focused primarily on perennial species, although fragmentary remains permitted identification of a number of annuals.

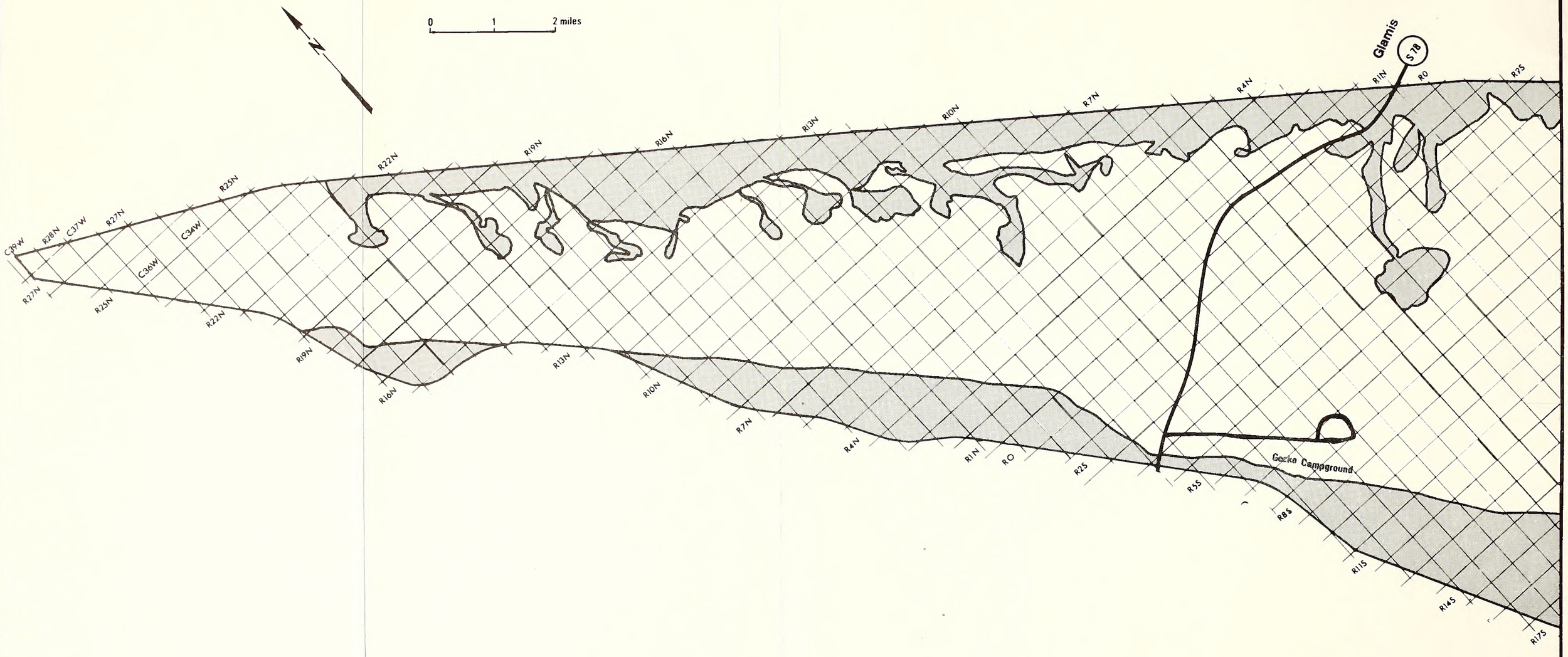


FIGURE 2-1

Grid System and Major References

Southern Pacific Railroad

R5S R8S R11S R14S R17S R20S R22S R26S S34 R29S R32S R35S Int B R38S R41S R42S

C42E C39E C36E C33E C30E C27E C24E C21E C18E C15E C12E C9E C6E C3E C0 C2W

R20S R23S R26S R29S R32S R35S R38S R41S R44S

C17E C18E C21E C24E

Int B

All American Canal

Coachella Canal

MEXICO

BOUNDARY
MAJOR SAND AREA

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The field survey phase of the study was accomplished by two basic methods. In the areas open for Off-Road Vehicle (ORV) use, field teams were transported by dune-adapted vehicles, whereas in areas closed to ORV use, field crews were staged by helicopter.

In areas open to ORV use, three two-man field teams were transported in four-man dune-adapted vehicles. In addition to the two biologists, each vehicle was operated by an experienced driver familiar with conditions in the dunes. Traverses were made across the dune system maintaining an equidistant course between east-west grid lines. Most traverses were made from west to east to take advantage of the gentler slopes on the western faces of the dunes. The three vehicles were driven along the east-west traverses in parallel routes one-half to one mile apart depending upon the type of terrain and the type of vegetation encountered. The dune area south and west of the main All-American Canal was surveyed by north-south running traverses between Interstate 8 and the International Boundary due to topographic and access features of that portion of the survey area. Dune-adapted vehicles were linked by radio to aid in coordination of vegetation analysis and navigation and as a safety measure. Vehicles were driven in a slow and careful manner to allow proper observation by the team members. Frequent stops were made to allow foot inspection of areas of interest and to perform vegetation analysis.

Each team member was provided with printed strip topographic maps of the traverse routes on which vegetation and floristic data were recorded. In addition, each team had a full set of USGS topographic maps of the dune system. North-south navigation was accomplished by following a standard compass heading. Course bearings were made both on nearby and distant landmarks on the beginning of each traverse. Headings were checked frequently to minimize drift. East-west navigation within the grid system was accomplished by several methods. Primary navigation was accomplished through identification of major topographic features on the USGS topographic map. This method was augmented through the use of markers placed on peaks by helicopter and through radio coordination among all three field teams.

Quantitative analysis of natural vegetation required various techniques due to the sparse local distribution of the plants. To demonstrate composition of the various plant associations, line intercepts of 200 feet were made as described by Mueller-Dombois and Ellenberg (1974). Dominance, relative dominance, frequency, and relative frequency were calculated for each species in each transect. The results allowed a general quantification of the species composition and their relative densities in representative stands. The approximate location of these transects are shown in Figure 2-2.

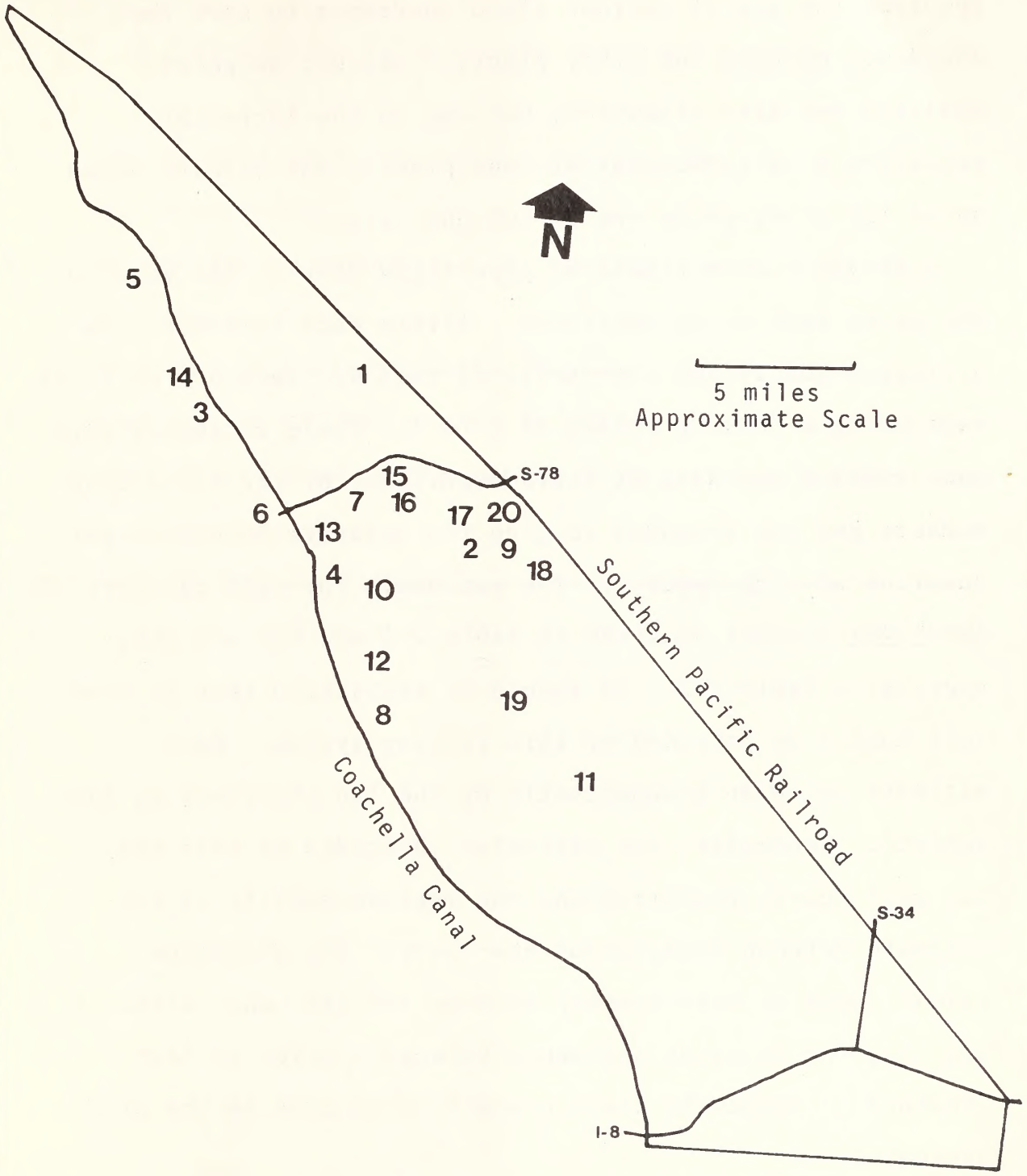


FIGURE 2-2 Line Intercept Locations

The host-parasite relationship of Ammobroma sonorae required the use of various sized quadrants to show the abundance of host and other plants. Nearest neighbor analysis was also attempted, but due to the incredibly extensive root structures of dune plants, the results based on aerial plant parts are of dubious value.

Finally, an estimate of population density was made for the seven taxa being monitored. Within each quadrant, the estimated density of the monitored taxa was recorded on strip maps using a ranking system of 1 to 4. These estimates were made after a few days of field experience by the field team members and are intended to give the relative abundance per quadrant of each species. The rationale for each category for Ammobroma sonorae is given in Table 2-2 and for all other species in Table 2-3. It should be emphasized that no absolute number is intended by this ranking system. Each estimate was made independently by the two observers on each vehicle. Generally, the estimates coincided or were only one unit apart, demonstrating the reproducibility of the estimate between independent observers. The abundance values have no relationship between species, only within a species. The relative abundance between species is best obtained by comparing their overall occurrence in the grid system.

In addition to a qualitative estimate of the density of the seven taxa, the vegetation association occurring in each quadrant was also noted on the strip map. A vegetation

TABLE 2-2

DESCRIPTION OF ABUNDANCE UNITS FOR *AMMOBROMA*

1 -- One to five inflorescences observed, most being dried inflorescences.

2 -- Six to twenty inflorescenses observed, some still with flowers.

3 -- Over twenty inflorescences in stand, but localized.

4 -- Over thirty inflorescences in stand, many in flower state and well distributed in depression or vegetation habitat zone.

TABLE 2-3

VEGETATION ASSESSMENT CRITERIA

Abundance Number[1]	Density Description
1	Presence of one or more plants occurring in low numbers, particularly adjacent to the observer, but not conspicuous farther away.
2	Presence of a moderate number of a species. Visible at a distance of up to ¼ mile from the observer.
3	Presence of moderately high number of species forming a conspicuous element of the landscape.
4	Presence of very high numbers of species occurring throughout the quadrant, representing some of the most dense populations encountered during the survey.

[1] The Abundance Numbers are relative values, allowing comparison of population sizes per traverse quadrant within a species only.

checklist of all plant species for each vegetation association was compiled for all traverses. Samples of most species encountered were taken and made into herbarium specimens.

Field surveys of areas closed to ORV use were made by helicopter and by two-man ground crews staged by the helicopter. Initial assessment of vegetation was made by helicopter, flying at a slow speed at approximately 50 feet above ground surface. Numerical ranking of densities of sensitive plant species and location of vegetation associations were recorded on printed strip topographic maps in the same manner as done by the vehicular survey in the open ORV areas. After completion of the aerial survey, two-man ground survey teams were placed by helicopter in areas requiring further analysis including possible habitats for Ammobroma sonorae. After completion of the ground survey in the ORV closed area, field crews were airlifted into other areas of the dunes requiring additional analysis.

Upon the completion of each day's work, field crews held nightly meetings to transfer all field plotted data onto complete overview maps as well as to discuss the day's observations and/or related survey matters. After completion of the field survey portion of the study, an overall map of the vegetation associations was compiled from the strip maps. Boundaries of these vegetation associations

were verified with the use of aerial photographs. Density numbers for each sensitive species were plotted for each quadrant on individual maps.

Six sand samples were taken within the dune system. (Figure 2-3.) Sand samples were analyzed using the Tyler Standard Screen Scale with the Tyler Sieve Shaker. This allowed the grain size composition of the sand samples to be determined.

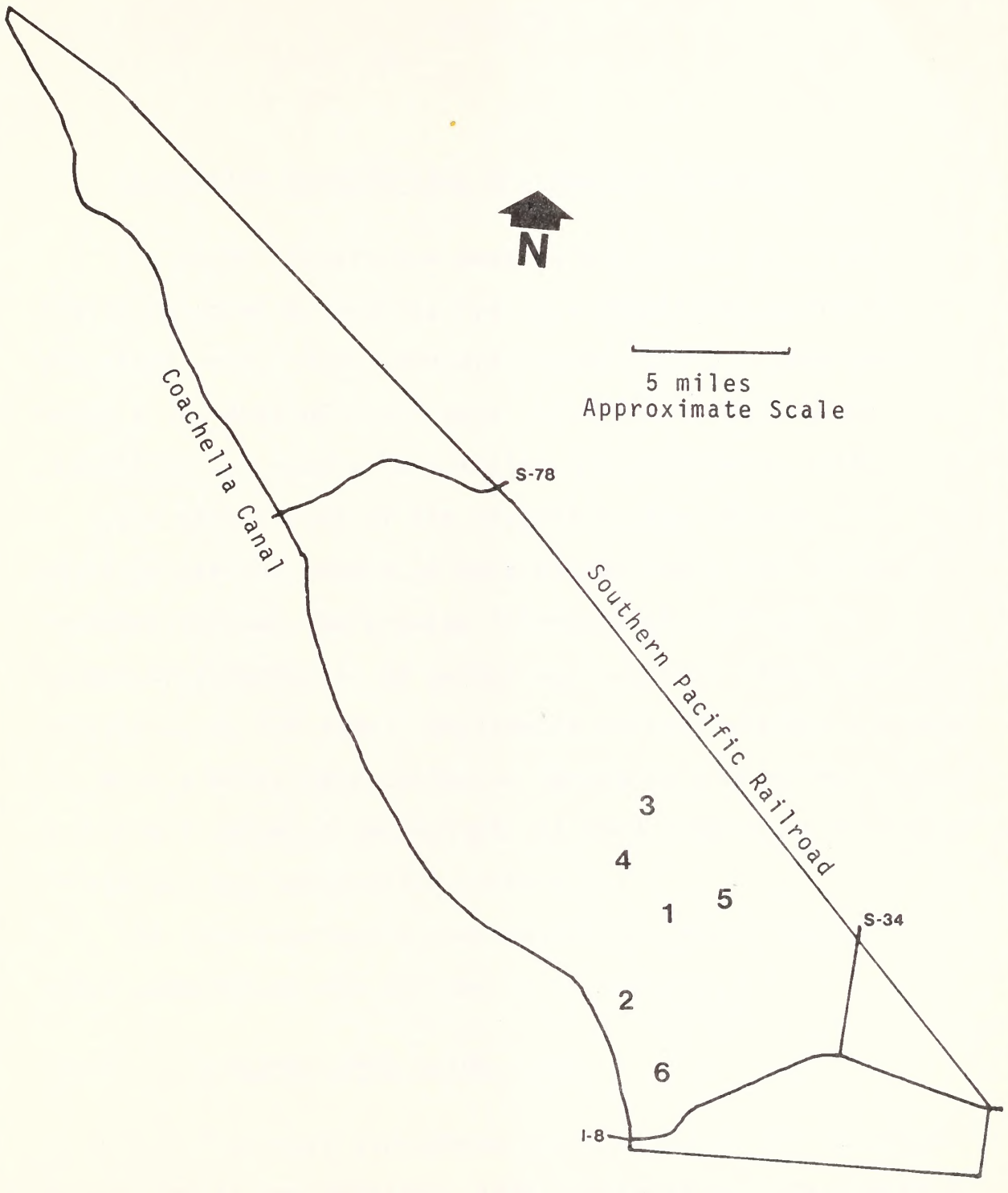


FIGURE 2-3 Sand Sample Locations

SECTION 3.0

RESULTS

3.1 Vegetation Associations and Species Diversity

The recent vegetation association scheme of Thorne (1976) appeared to reflect best the vegetation observed in the study area. Five categories were firmly established after a few days of field work, including a helicopter flyover of the entire dune system and peripheral areas.

The preparation of the vegetation map (Figure 3-1) utilized several levels of data collection. The vehicular traverse allowed the precise recording of ecotones or community interfaces, as permitted by ground navigation conditions at the time. Helicopter surveys allowed a broader, more general delineation of community boundaries. The use of U-2 infrared photography allowed comparison of survey routes and the large scale picture.

The five vegetation communities are discussed below. These communities are delineated in Figure 3-1.

3.1.1 Creosote Bush Scrub (CBS)

This most widespread association of the Colorado Desert (Wells and Hunziker, 1976) occurred on both flanks of the dune system and, rarely, in some central sink areas.

The dominant species was Creosote Bush (Larrea tridentata) and the densities of the shrub vary tremendously within areas mapped as CBS. This variation in density is illustrated on line intercept results tabulated in Appendix C.

On the west flanks, almost pure stands of Larrea tridentata occurred. Percolation from the nearby Coachella Canal appeared to enhance the growth of the shrubs which reach over four meters high adjacent to the portion of the canal. Transitional to the sandy dune area, the species diversities increased with the addition of Ambrosia dumosa and Coldenia palmeri. Several alkaline open areas supported low stands of Aristida californica.

The Creosote Bush Scrub of the eastern flank of the dunes was much more diverse due to the topographic relief of invading dunes and to the runoff from the Chocolate and Cargo Muchacho Mountains. Baileya pleniradiata, Oenothera deltoides, Dalea emoryi, Ephedra trifurca, Datura discolor, Hilaria rigida, Hymenoclea salsola, Krameria grayi and Stephanomeria pauciflora were also conspicuous members of the Creosote Bush Scrub community.

3.1.2 Desert Microphyll Woodland (DMW)

Runoff channels of the western alluvial fan of the Chocolate and Cargo Muchacho Mountains terminate into the eastern flank of the dune system. Along these channels

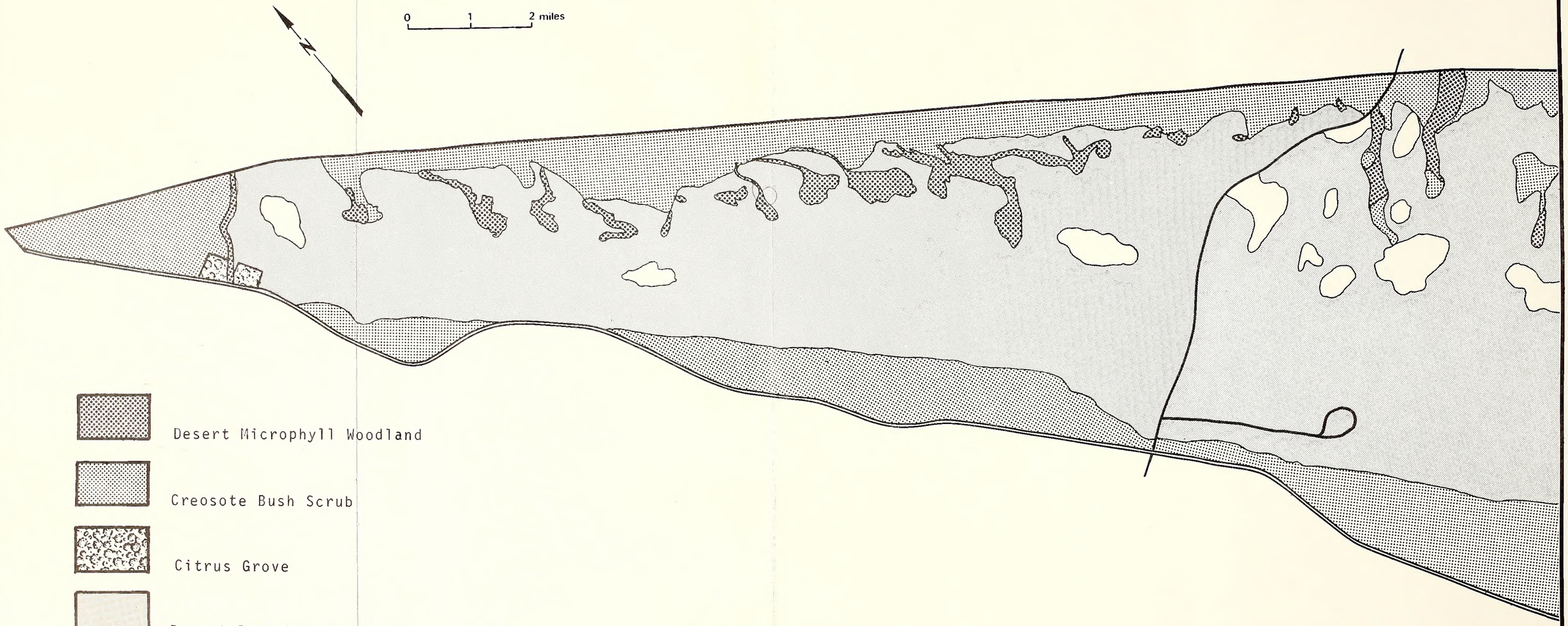
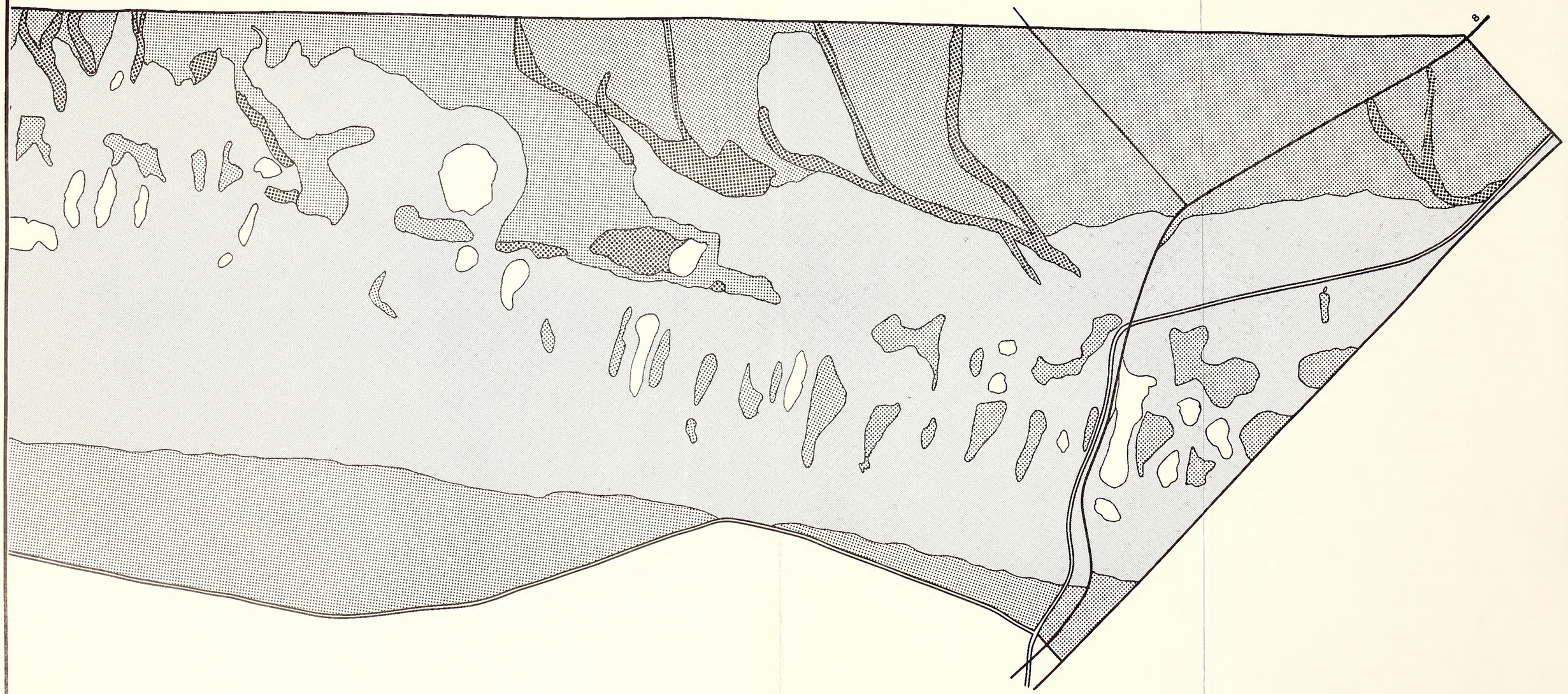


FIGURE 3-1

Vegetation Associations



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and about the cul-de-sac sinks of their termini, grew such arborescent species of the region as Chilopsis linearis, Cercidium floridum, Prosopis glandulosa and Olneya tesota. The understory growth commonly consisted of Brandegea bigelovii, Sphaeralacea orcuttii, Aristida californica, Schismus barbataus, Oligomeris linifolia and Asclepias subulata.

Because of the meandering of the channels, elements of the Creosote Bush Scrub and Desert Psammophytic Scrub were often mixed with Woodland elements as well as each other. Some Woodlands penetrated the dunes along the eastern flank and served as landmarks. The penetration of this Woodland permited movement of deer between the Woodland and the Coachella Canal over the narrowest portion of the dune system.

3.1.3 Canal (CAN)

The presence of the All-American and Coachella Canals has introduced a hydrophytic vegetation into the dune area. Generally, the plants are weedy species which require periodic irradication from the Canal. These plant species included Myriophyllum exalbescens, Potamogeton pectinatus, and Polygonum fusiforme. On the canal bank, above the water level, such weedy species as Conyza canadensis, Aster spinosus, Arundo donax, Eclipta alba, Helianthus annuus, Melilotus albus and Pluchea sericea were found.

3.1.4 Desert Psammophytic Scrub (DPS)

The dune portion of the study area was covered by vegetation adapted to relatively high sand mobility and deep water percolation. Common species were Petalonyx thurberi, Eriogonum deserticola, Panicum urvilleanum, Helianthus niveus ssp. tephrodes, Ammobroma sonorae, Astragalus magdalenae var. peirsonii, Ephedra trifurca, Croton wigginsii, Dicoria canescens and Coldenia plicata. In more stable portions of the dunes, usually transitional to a sink or scrub area, Oenothera deltoides and occasionally Hesperocallis undulata occurred.

3.1.5 Open

Lack or nearly the lack of cover was subsumed in this category. The lack of cover was due to the high mobility of the sand surface or to intensive ORV use. Occasionally open areas sustained Helianthus niveus ssp. tephrodes or Panicum urvilleanum.

3.1.6 Vegetation Analysis

Line Intercept vegetation analyses were made within representative areas of the Creosote Bush Scrub, Desert Microphyll Woodland and Desert Psammophytic Scrub. The location of these transects are shown in Figure 2-2 and are tabulated within Appendix C for each vegetation association.

The results of this vegetation analysis generally conformed with observations discussed in the previous sections. Larrea tridentata was the dominant species within the Creosote Bush Scrub with relative dominance values ranging between 46.27 and 90.08. Other important species in the vegetation association include Ambrosia dumosa and Ephedra trifurca, Croton wigginsii, Eriogonum deserticola, Palafoxia arida var. gigantea and Dicoria canescens were dominant plant species within the Desert Psammophytic Scrub. Higher Croton wigginsii values were recorded on the western portion of the dunes. The Desert Microphyll Woodland showed a high species diversity in the two transects recorded.

3.1.7 Species Diversity

The observed floral diversity of the study area amounted to 114 plant taxa (see Appendix B). Floristically, the most diverse association was the Creosote Bush Scrub, particularly the eastern flank with 22 taxa. The Desert Psammophytic scrub areas contained 20 taxa, the Desert Microphyll Woodland contained 21 taxa and the Canal area contained 16 taxa (most of which were weedy species).

The lateness of the season made identification of the very fragmentary remains of most of the annual species difficult. A significant number of additional plant taxa no doubt occurred in the study area; however, the brief survey

and late season did not permit their detection. Aside from the unique dune endemics, the flora of the area is typical of the eastern Colorado Desert of California.

3.2 Habitat and Distribution of Sensitive Plant Species

Seven of the eight sensitive plant taxa identified in Section 1.3 were identified in the field survey. Pilostyles thurberi was the only taxon not found during the survey. A discussion of each sensitive plant species found is contained in the following subsections.

3.2.1 Ammobroma sonorae (Proposed Endangered)

Ammobroma sonorae occurred throughout the dune system as shown in Figure 3-2. Initial indications were that populations of the host plant, Coldenia plicata, being more visible than the Ammobroma, should be sought out and examined. This method proved useful initially until field workers became familiar with the particular habitat requirements of the species.

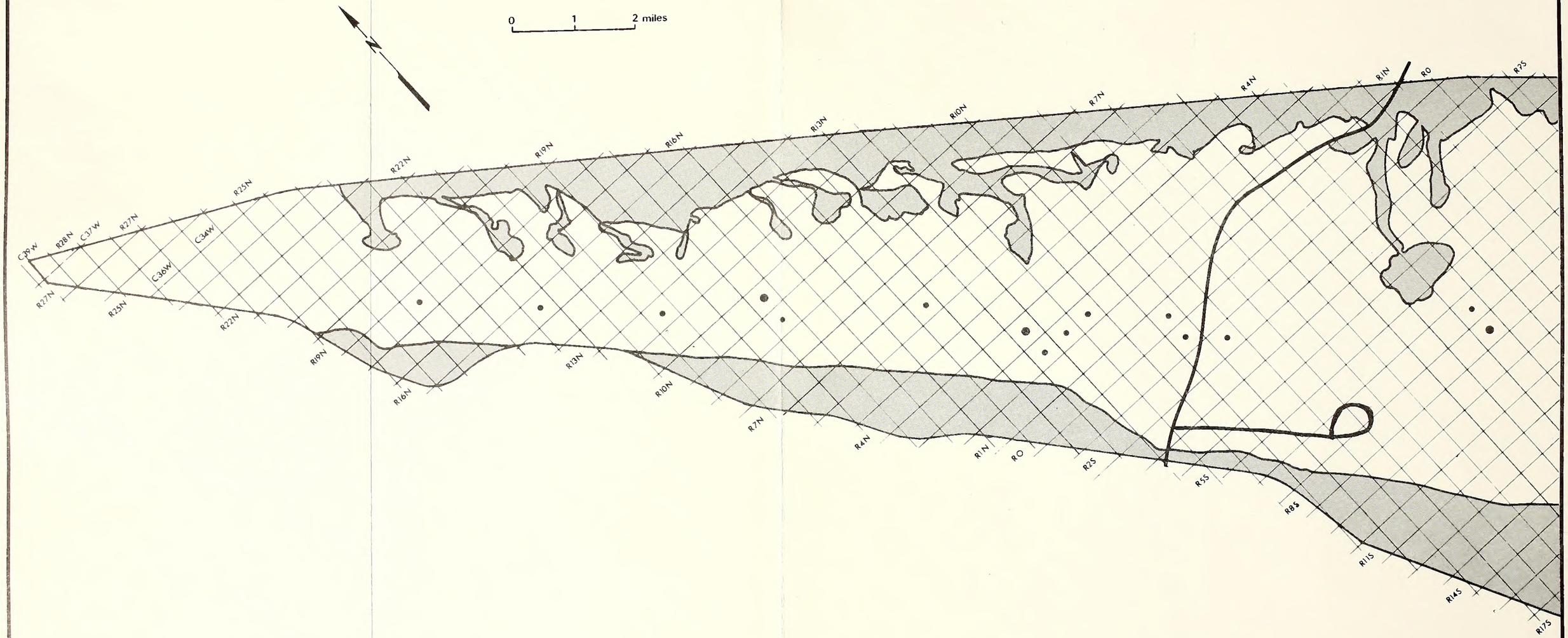
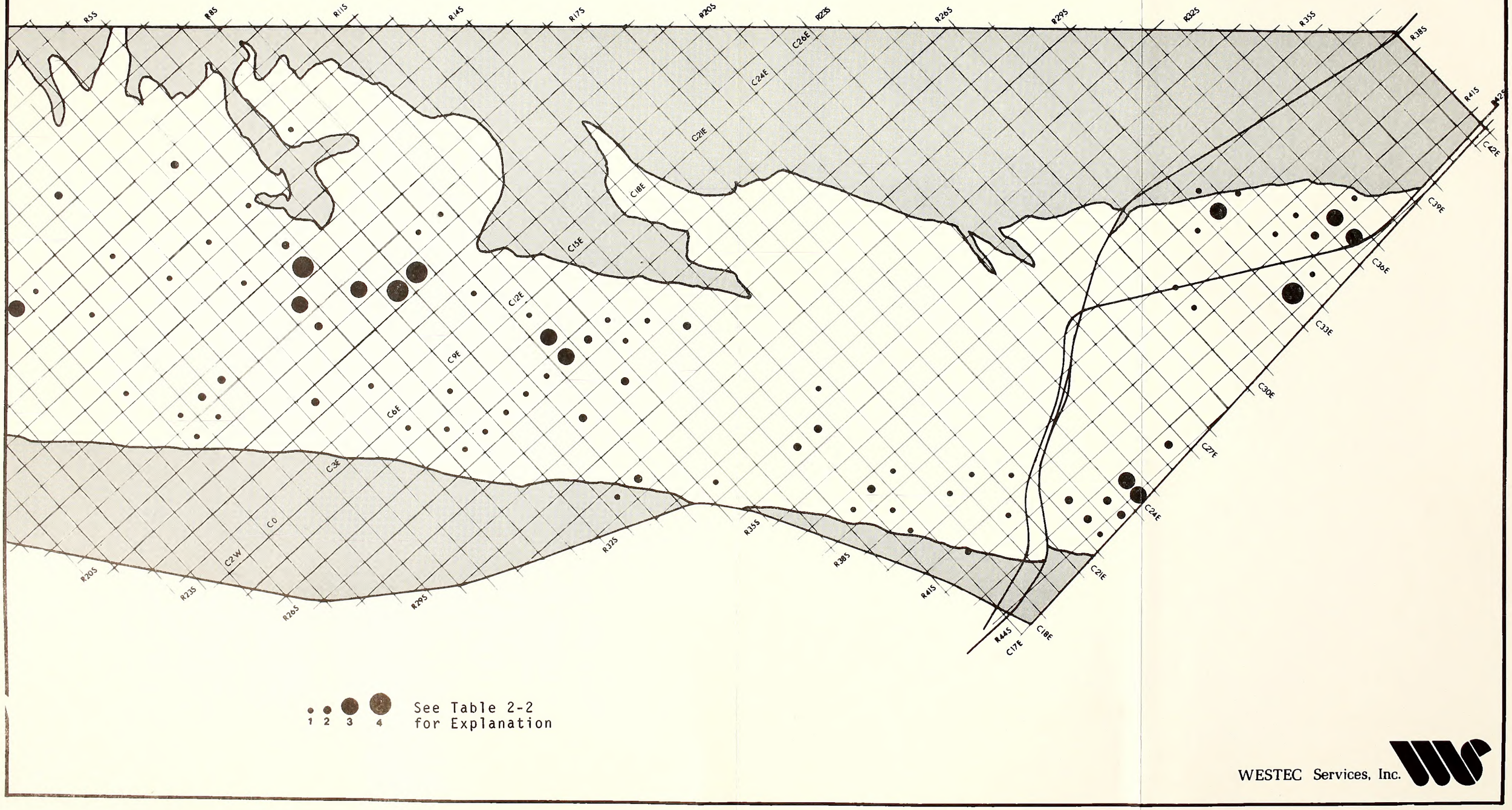


FIGURE 3-2

Quantitative Distribution Map
Ammobroma sonorae



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The parasite occurred generally on stabilized sand slopes or level areas. Because of the prevailing wind situation, these stable slopes usually had a western aspect (generally from 325° to 325° true). Adequate growth of host plants in the area is also necessary, although proximity of Ammobroma inflorescences to host plants varied considerably due to the extensive root system of both the host plant and Ammobroma. Ammobroma itself occurred to depths exceeding five feet.

Aside from confirmed haustorial connections with Coldenia plicata, (see Figure 3-3) a connection with Eriogonum deserticola was discovered. Because of the rare, endemic nature of the Ammobroma, no systematic attempt was made at unearthing haustorial connections to confirm host-parasite relationships. Two other highly suspect associations were observed with Coldenia palmeri and Croton wigginsii.

The major portion of the Ammobroma population in the Algodones Dunes was found to be past flowering condition. However, many inflorescences with flowers on the outer periphery were still functional, indicating centrifugal development of the flowering structure. Highest densities of Ammobroma stands were found between Rows R17S and R27S in the central axis of the dunes and in the southernmost portion of the dunes south of Interstate 8 (see Figure 3-2).

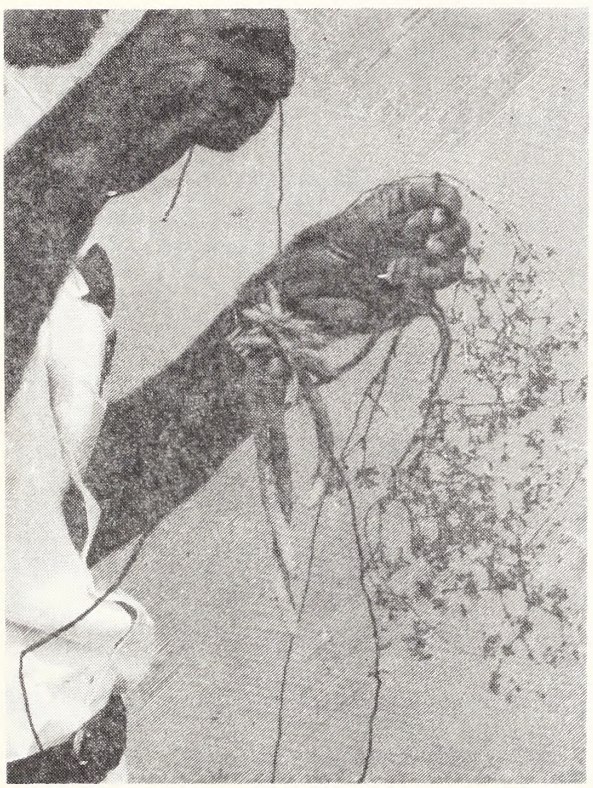
Stands of Ammobroma are known to occur on the East Mesa area, but no specimens were found during brief surveys of the Creosote Bush Scrub areas west of the Coachella Canal. However, a few plants were encountered on the east Coachella Canal bank. A high percentage of Ammobroma in the study area occurred in the dune area rather than the peripheral Creosote Bush Scrub areas.

During the survey, diurnal activity of hymenopterous pollinators was observed. Gene flow no doubt occurred within the various depressions and slopes where the stands were found. Gene flow between local populations probably occurred nocturnally when the majority of dune insects are active. Biologically, therefore, the entire Ammobroma distribution in the Algodones Dune system could be considered one interbreeding population. Dune systems to the southeast, in Sonora, Mexico, would appear to have separate Ammobroma populations.

Reproduction of the Algodones Dunes Ammobroma population appear to be sustaining. The mode of seed dispersal and germination was not observed.

Because of the random occurrence of Ammobroma microhabitats in the dune system, the essential habitat for Ammobroma appears to be the entire sand mass.

Ammobroma Inflorescences With Flowers On Outer Periphery



Young Parasitic *Ammobroma* On Root Of *Coldenia plicata*

FIGURE 3-3

Ammobroma sonorae

3.2.2 Astragalus lentiginosus var. borreganus (Rare and Endangered - California Native Plant Society)

This plant, infrequently found in the survey, occurred only in small depressions on the east side of the system (see Figure 3-4). A few depressions, usually surrounded by dunes up to 2-3m high contained seedlings up to 10cm high and older plants to 30cm high. The plants were well past the flowering stage with many of the legumes already dehisced and the pods fallen.

Apparently, as witnessed from water marks on the sides of the depression, the east side of the dune system was a mosaic of ponds after the onslaught of tropical storm Kathleen in September, 1976. This high volume of water was apparently responsible for the abundant seedlings in the depressions. Within the Colorado Desert (in southeast California), populations are known from Borrego Valley, Coachella Valley, and Algodones Dunes as well as the Yuma Desert to the east. The occurrence of the variety on the east side of the Algodones Dunes may represent two or more populations due to the wide gaps in their distribution. The essential habitat of this variety within the Algodones Dunes appears to be the small dune depressions (ranging in size from 10 to 80m across) on the east side of the system.

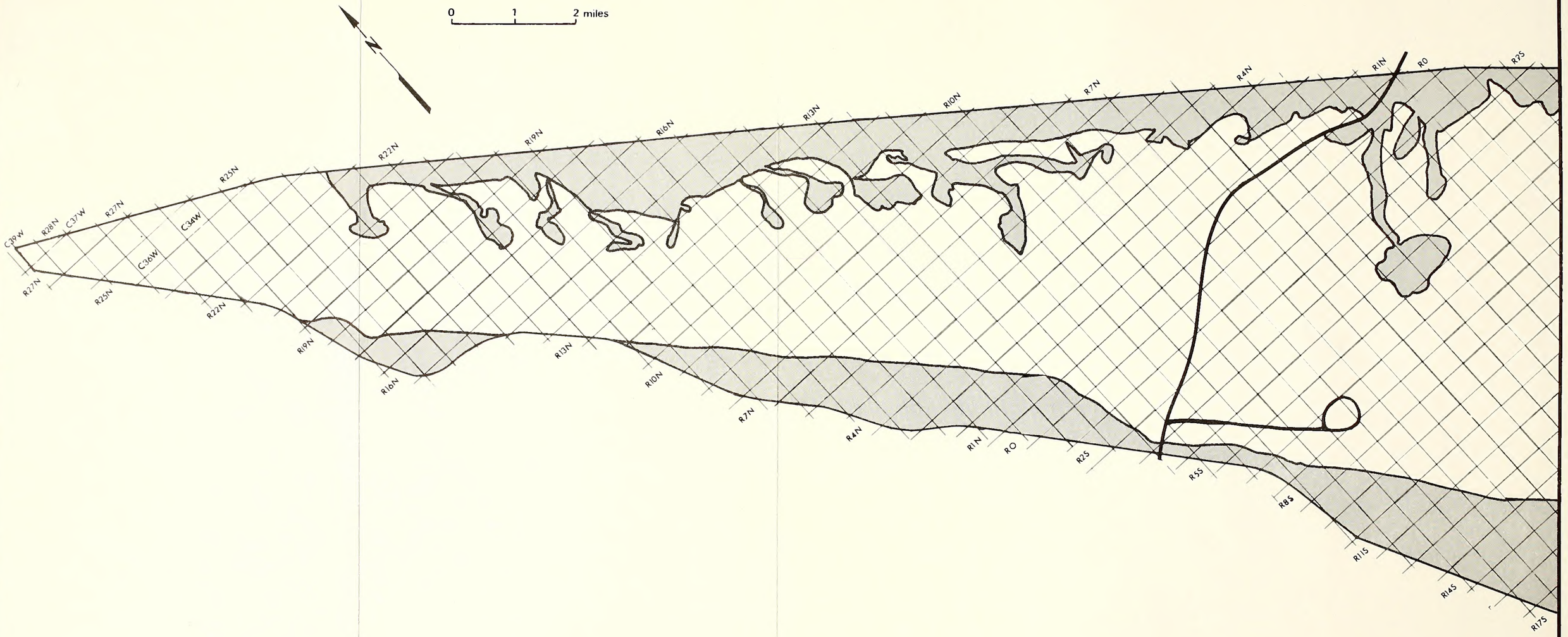


FIGURE 3-4

Quantitative Distribution Map
Astragalus lentiginosus var. borreganus

R5S R8S R11S R14S R17S R20S R23S R26S R29S R32S R35S R38S R41S R42S

C42E C39E C36E C33E C30E C27E C24E C21E C18E C15E C12E C9E C6E C3E C0 C2W

R20S R23S R26S R29S R32S R35S R38S R41S R44S C17E C18E C21E C24E

1 2 3 4 See Table 2-3 for Explanation

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3.2.3 Astragalus magdalenae peirsonii (Rare and Endangered - California Native Plant Society)

This milk-vetch is a distinctive member of the genus Astragalus, having the largest seeds of the American members. These plants have a distinctive single trunk for one-third to one-half of their height, eventually branching into a broom-like growth of smaller stems (see Figure 3-5). No flowers were seen during the survey, with most plants past the fruiting stages.

The plants are best developed in characteristically conically-shaped hollows on the western half of the dune system as shown in Figure 3-6. Generally, the plants occur on the windward side of the hollows, although exceptions are frequent. In several hollows, it was noted that the plants occurred in a line down the side of a slope (Figure 3-5). Initially, it was hypothesized that the plants were sprouting from an underground runner. However, it was later found that the seeds were being sorted and deposited by wind. The extremely straight line of seed deposition is apparently due to unusual venturi action of the prevailing winds as they pass across the conical depressions.

This Astragalus is restricted to the dunes of the Algodones system as well as one system in the Borrego Valley. The occurrence of the plant in the Algodones Dunes constitutes one of only two populations known. The essential habitat of

Stand In Linear Arrangement Showing Main Stem And Branching Aerial Portion

Shrub In Fruit Showing Beaked Legumes And Reduced Leaflets.

FIGURE 3-5

Astragalus magdalenae var. peirsonii

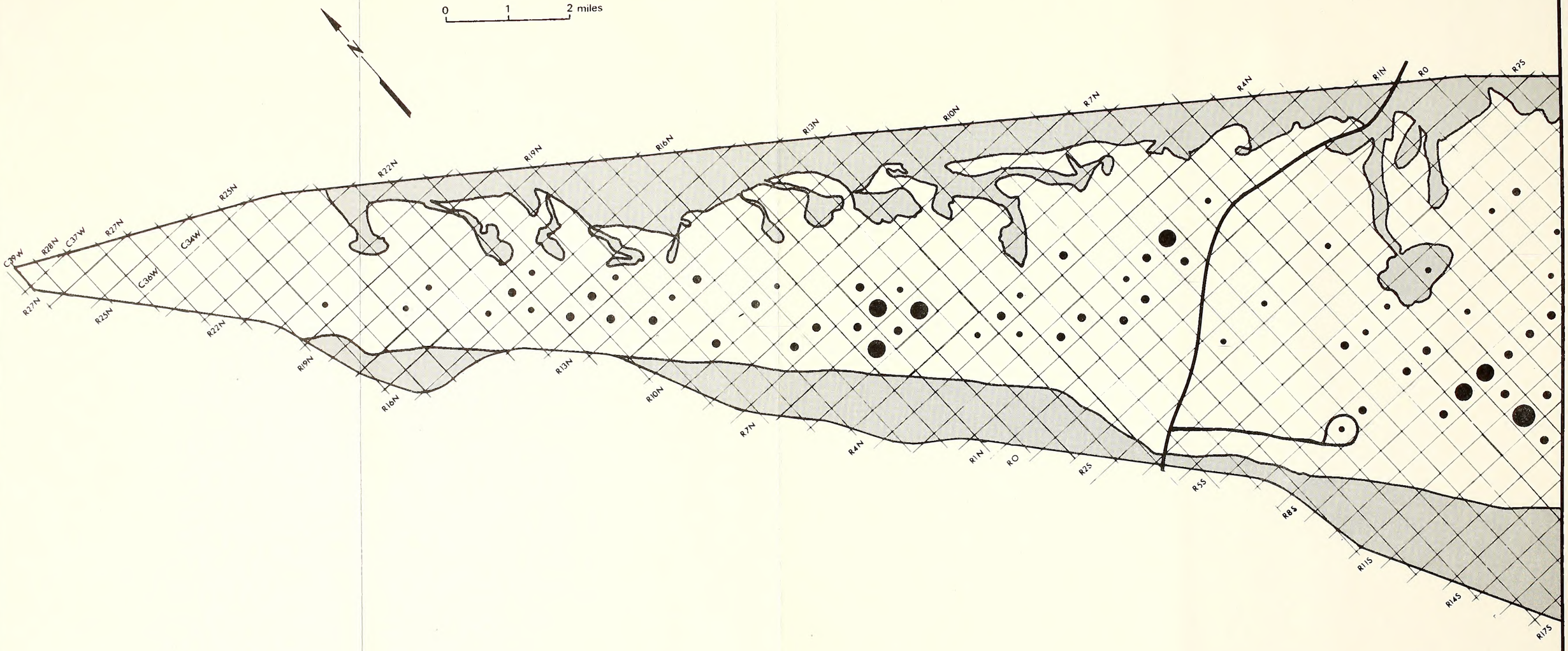
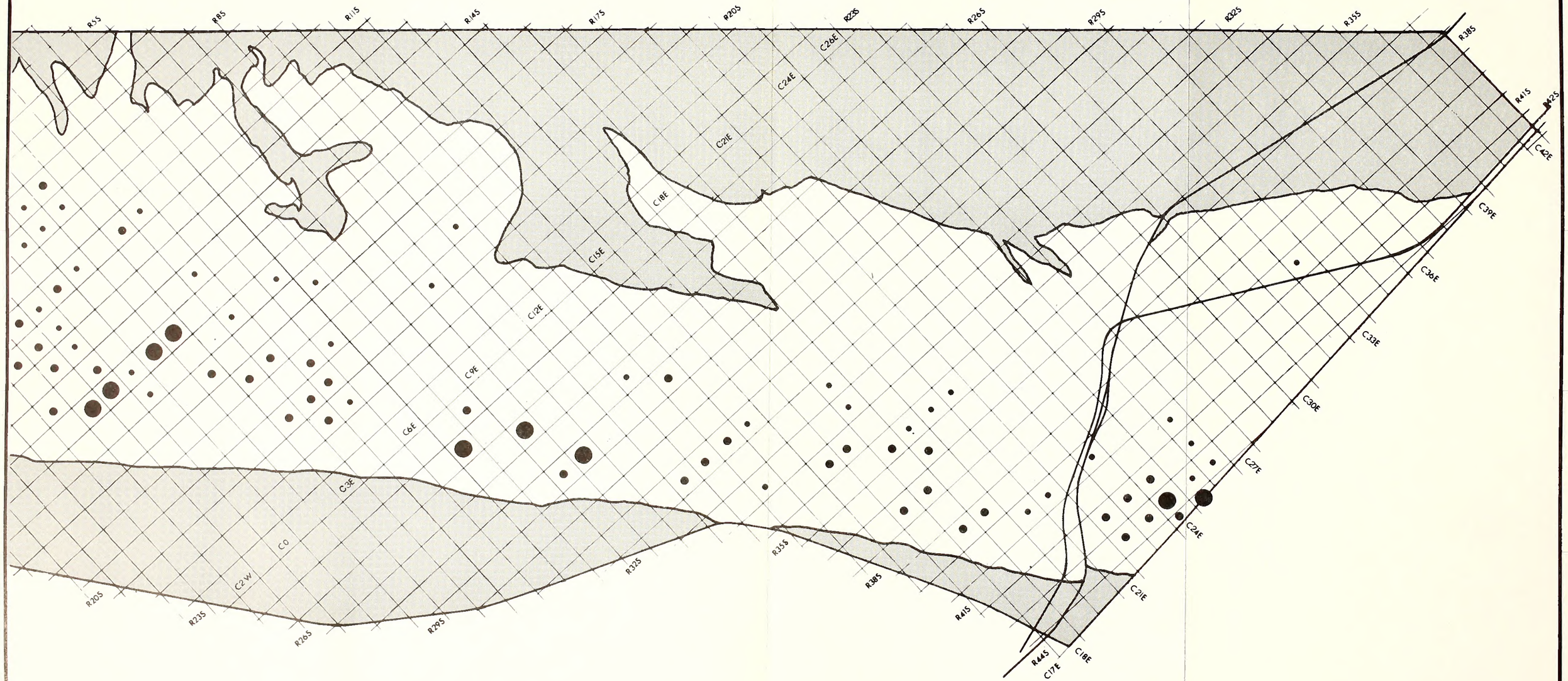


FIGURE 3-6

Quantitative Distribution Map
Astragalus magdalenae var. peirsonii



1 2 3 4 See Table 2-3 for Explanation

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the plant includes depressions and stable slopes especially in the western and central portions of the dune system.

3.2.4 Croton wigginsii (Proposed Endangered)

From nearly the start of survey, the low numbers of Croton wigginsii on the eastern portion of the dunes was apparent. Seventy-nine percent of the traverse quadrants recorded for Croton wigginsii were on the western half of the dune system (Figure 3-7). No large occurrences, with the exception of a population west of Pilots Knob, occurred on the eastern portion of the dunes. Locally, the plants occur in the more stable sand areas; however, significant numbers occur in active leeward slopes perhaps due to invasion and upward growth through the invading sand hills (Figure 3-8).

Although no attempt was made to quantify the sex ratio of the population, occurrence of staminate and pistillate plants seemed not to deviate from a 1:1 random distribution of the sexes. Two color phases were however, noted in the population. A blue-green and a gray phase appear to occur at random with either sex throughout the population.

Various sized plants occurred throughout the population indicating an active reproduction. Croton seedlings, approximately 10cm tall were frequent. The occurrence of this significant number of seedlings may be due to a high germination rate produced from tropical storm

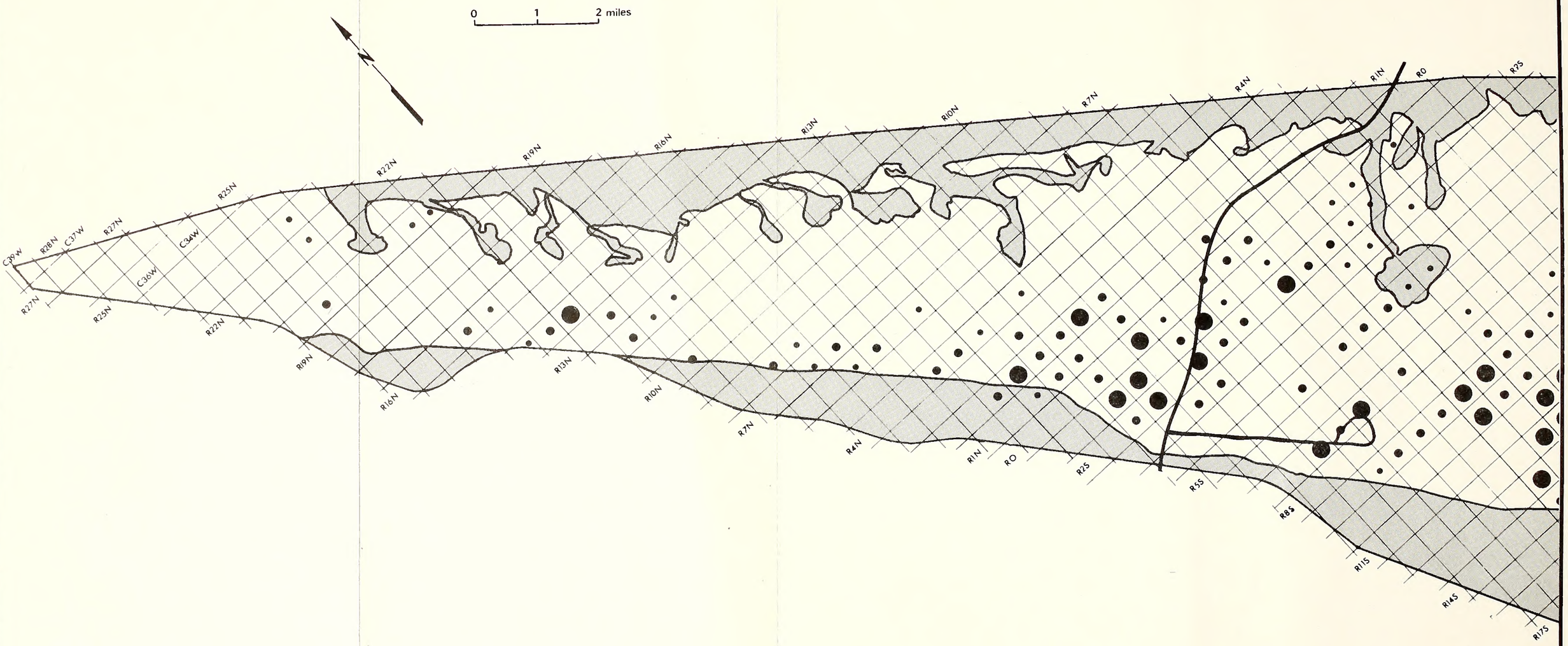
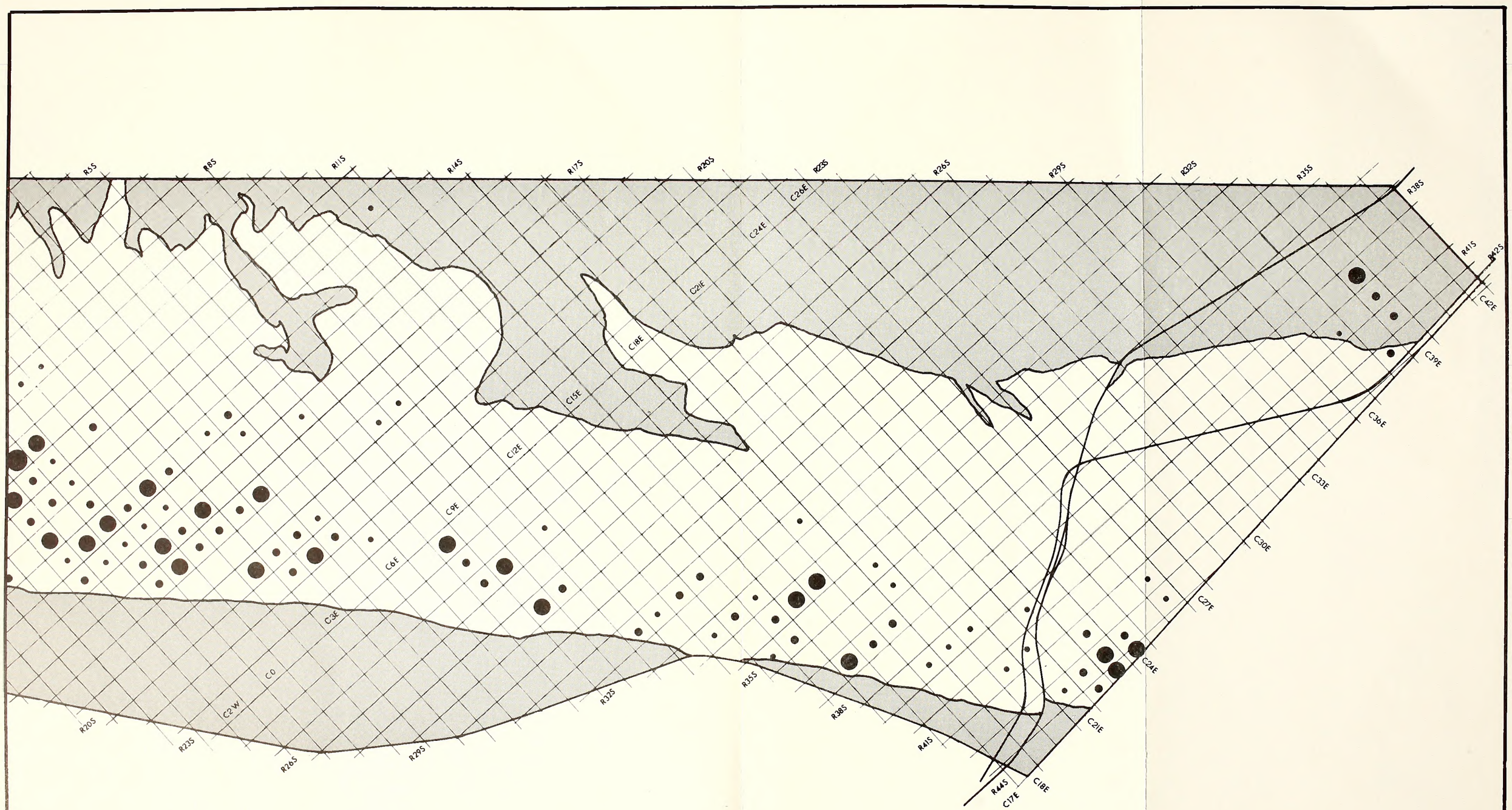


FIGURE 3-7

Quantitative Distribution Map
Croton wigginsii



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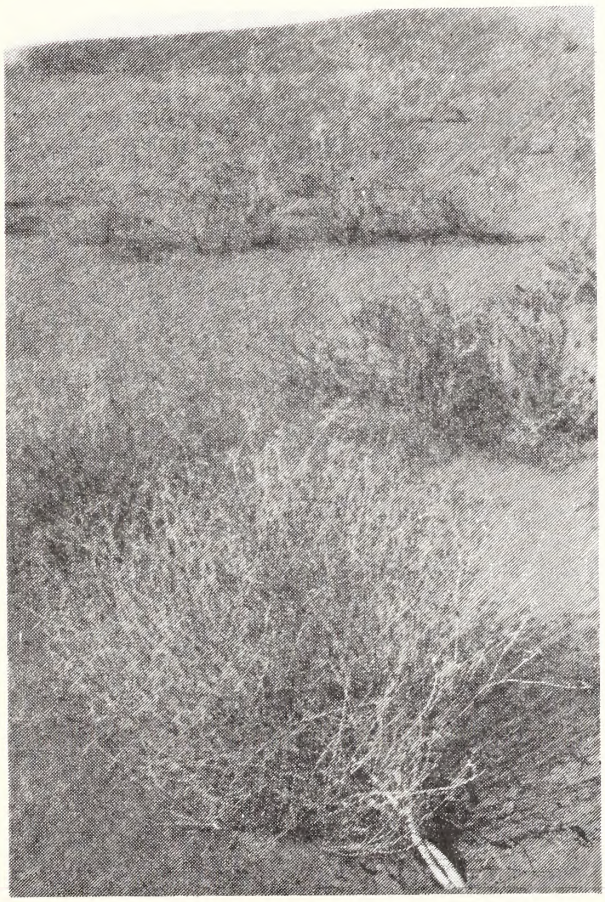
Stem With Fruit And Pistillate Flower Showing Pubescent Vesture



Shrub With Exposed Main Stems

FIGURE 3-8

Croton wigginsii

Kathleen. Masses of several dozen intertwined seedlings were observed. This phenomenon could be due to germination of seeds or fruits stored under the sand surface by rodents.

No pollinators were noted during the diurnal survey period. However, a mantid closely matching the coloration and shape of the Croton leaf was noted.

The two sexes of Croton wigginsii appeared to form one breeding system as shown by their proximity and apparent heterogeneous occurrence on the western half of the dunes. The western dune system would then represent the essential habitat for the population of Croton wigginsii within the United States.

3.2.5 Eriogonum deserticola (Proposed Threatened)

Eriogonum deserticola was the most widespread of the seven monitored species in the dune system, identified in 544 of the 1481 quadrants. The best developed Eriogonum deserticola populations were found in shallow washes on the east side of the dune system (Figure 3-9). The species formed solid, light blue zones along many dried water courses on the eastern portion of the study area. Large concentrations were also found in the dune areas.

The population was just beginning to flower during the survey. No pollinators were observed during the day.

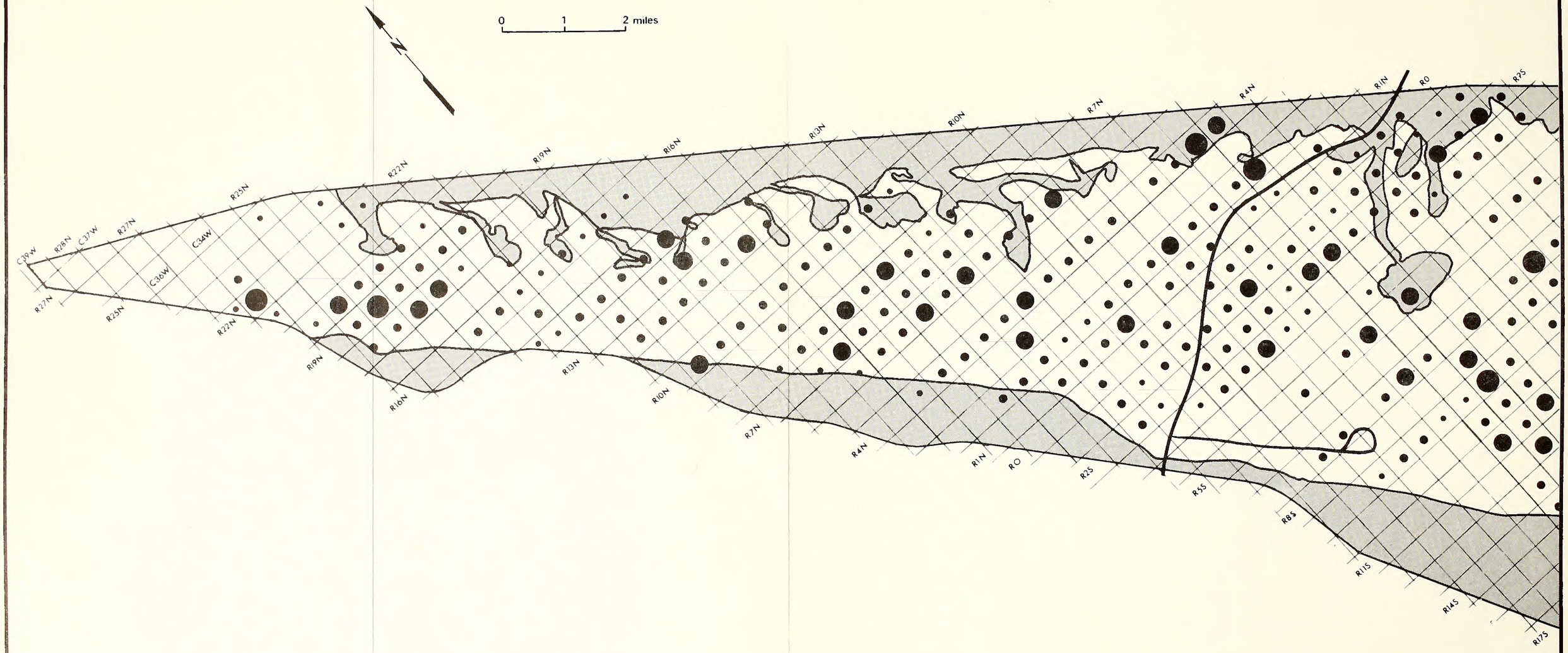


FIGURE 3-9

Quantitative Distribution Map
Eriogonum deserticola

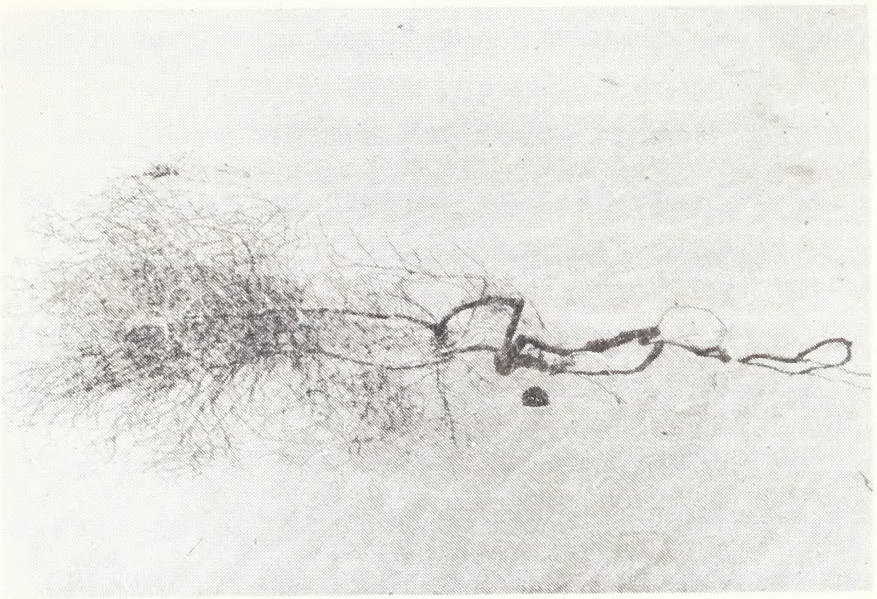
1 2 3 4 See Table 2-3 for Explanation

WESTEC Services, Inc.

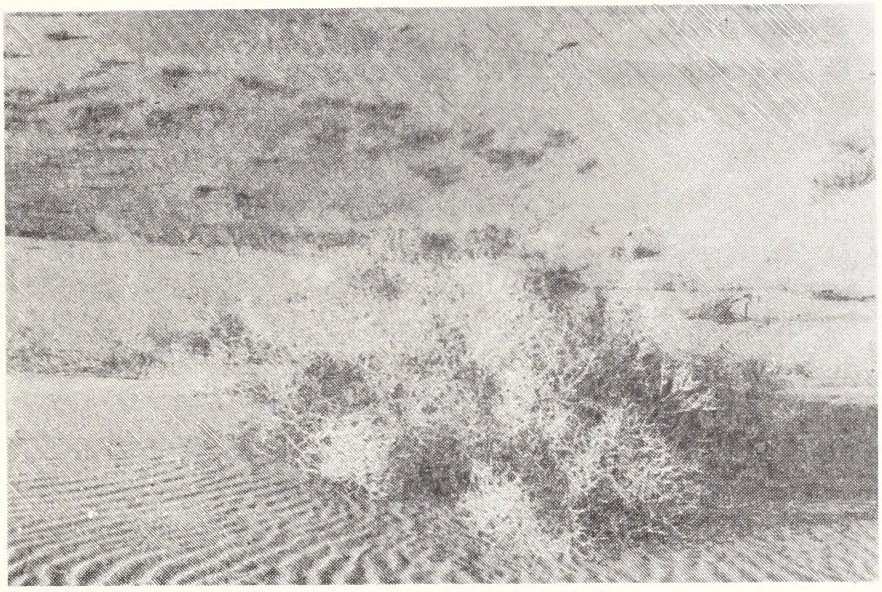
Two seedling size classes were noted during the survey. As observed with other dune endemics, the seedlings had very long roots and stem structures apparently enabling the plants to reach the moist portion of the sand quickly. Also, the long expanded stems on mature plants allowed the plants to rotate and bend in order to reduce the stressing effect of frequent winds (Figure 3-10).

Although more frequent in stable dune slopes, the Eriogonum occurred on mobile slopes, growing in the loose sand. As a host of Ammobroma sonorae, Eriogonum deserticola did not appear to undergo physiological stress as evidenced by lack of dead limbs or reduction of general vigor.

Distribution of Eriogonum deserticola within the study area would include the Algodones Dune system and the East Mesa area to the west. The plant occurred in the Mexican portion of the Algodones Dunes, but was not known from collections in Sonora, Mexico or in Arizona. Known populations would include the San Felipe Wash-West Mesa area, Mount Signal, and the East Mesa-Algodones Dunes population. The essential habitat of Eriogonum deserticola was not as well defined as other dune endemics, as it occurred within the Desert Psammophytic Scrub, Creosote Bush Scrub, and Desert Microphyll Woodland. A sandy substrate was apparently a primary prerequisite for the species. The most dense stands occurred on the east flank while the more uniform stands occurred in the dune system itself.



Living Shrub With Exposed Main Stem



Shrub Just Beginning To Flower. Note Distribution Of Shrubs In Background Relative To Active Dune Slope.

FIGURE 3-10 Eriogonum deserticola

3.2.6 Helianthus niveus ssp. tephrodes (Proposed Endangered)

The dune sunflower is best developed in active dune areas, especially along the central axis of the system (Figure 3-11). Clones were often observed on the mobile leeward faces of the dunes.

Large areas of seedlings were observed in various locations in the dune system. Two sizes of seedlings, one being being two to three centimeters and the other five to ten centimeters long, were observed. The class of larger seedlings may have germinated after the tropical storm in September, whereas the smaller seedlings could have germinated after spring rainfall. The number of seedlings was probably higher than the number of plants which would be accommodated with normal precipitation. A higher than normal mortality rate of the seedlings would be expected to occur.

As with the case of other dune endemics, the Helianthus produces a long root-stem structure which allows the seedlings to produce a root system down to the moist zone of the sand quickly. Aerial (Figure 3-12) growth appears to be reduced by concentration of energy into root growth. However, since sunlight is not a limiting factor in the dunes, this appears to be of minor consequence.

Many of the stands were blooming during the survey. No diurnal pollinators were noted.

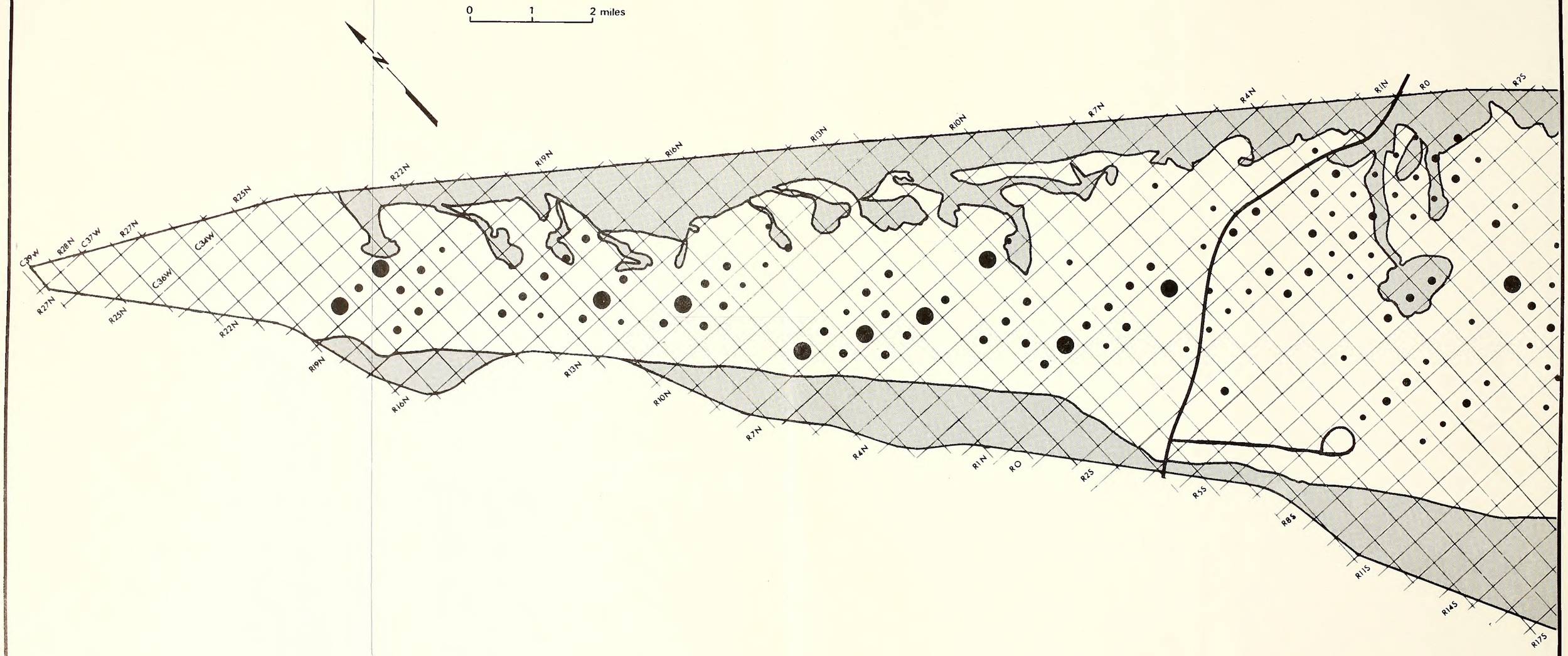


FIGURE 3-11

Quantitative Distribution Map
Helianthus niveus ssp. tephrodes

1 2 3 4 See Table 2-3 for Explanation

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Large Stand In Full Bloom On Active Dune Slope

Single Head With Foliage Showing Reflective Pubescence

FIGURE 3-12

Helianthus niveus ssp tephrodes

Although rather dispersed, the Helianthus occurs in a continuous distribution in the dune system. Because of this, gene flow would seem to occur readily throughout the population. The Helianthus in the Algodones Dune system apparently is the only California population of the subspecies, although other populations are known in Arizona and Sonora, Mexico. The essential habitat of Helianthus niveus ssp. tephrodes in the Algodones Dunes appeared to be in the more active dune areas.

3.2.7 Palafoxia arida var. gigantea (Proposed Endangered)

This larger variety of the common Palafoxia arida (P. a. var. gigantea) was apparently restricted to the Algodones Sand Dunes both in California and Baja California Norte. The larger Palafoxia arida var. gigantea was restricted to the dunes area, (Figure 3-13) with the smaller variety, (Palafoxia arida var. arida), much more widespread, occurring in the Scrub areas and low dunes to the east of the main dunes.

Various size classes of Palafoxia arida var. gigantea were observed in the dunes (Figure 3-14); however, no large expanses of seedlings were seen as was the case with some other dune plants. The variety may be either an annual or a short-lived perennial. The perennial habit was apparently due to a heavier than normal amount of precipitation in the dunes which prolonged the growing season of the normally annual plant into the next spring cycle.

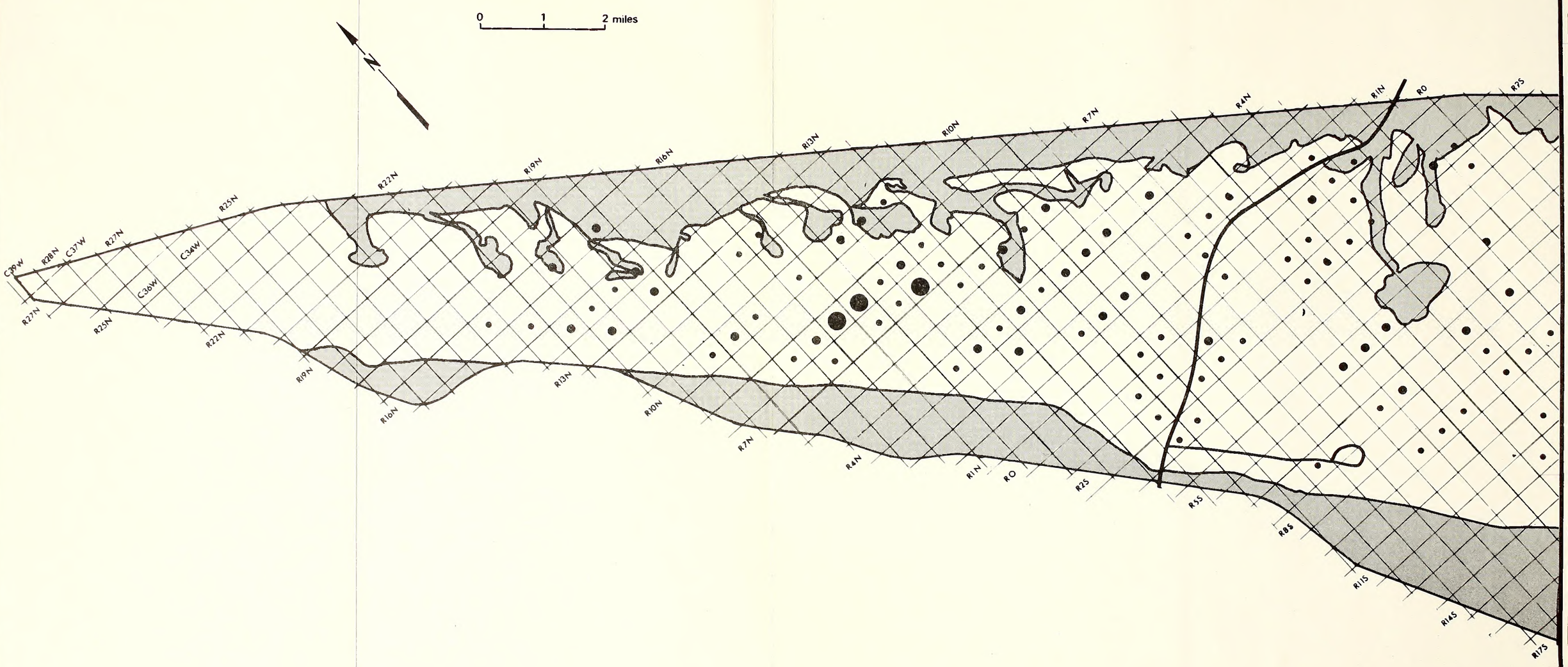

FIGURE 3-13

Quantitative Distribution Map
Palafoxia arida var. gigantea

R5S R8S R11S R14S R17S R20S R23S R26S R29S R32S R35S R38S R41S R42S

C2E C3E C6E C9E C12E C15E C18E C21E C24E C26E C27E C30E C33E C36E C39E C42E

C0 C2W

R20S R23S R26S R29S R32S R35S R38S R41S R44S

C17E C18E C21E C24E C27E C30E C33E C36E C39E C42E

1 2 3 4 See Table 2-3 for Explanation

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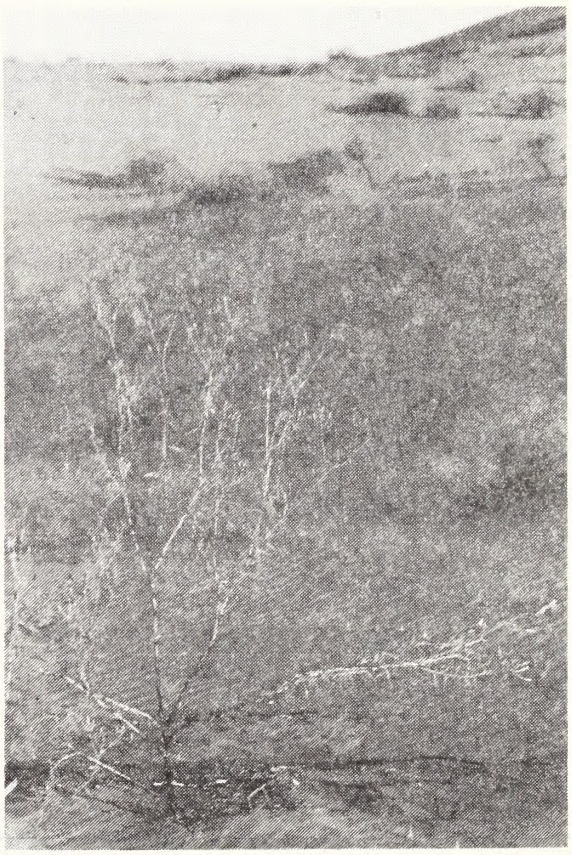
Heads Showing Florets With Stigmas Exserted



Meter-Tall Specimen In Bloom

FIGURE 3-14

Palafoxia arida var. gigantea

Palafoxia arida var. gigantea occurred throughout the dune system. There appeared to be no particular distribution differences for stable or active dune areas. The entire distribution constitutes a single population, the only one in existence. Therefore, the essential habitat would be defined as the entire sand mass of the system.

3.2.7 Comparison of Distribution of Sensitive Plant Species

Table 3-1 generally summarizes the distribution of all seven plant species occurring within the study area. Figure 3-15 graphically illustrates this distribution. Of all species surveyed, Eriogonum deserticola was the most widely distributed, occurring in 544 out of 1,481 quadrants in the study area. Palafoxia arida var. gigantea and Helianthus niveus ssp. tephrodes were also widely distributed, occurring in 276 and 257 quadrants respectively.

Figure 3-16 illustrates the areas of highest concentration for each of the seven sensitive plant species. This map was prepared by plotting the location of all "3" and "4" abundance units for each species.

3.3 Soil Analysis Results

Six sand samples were analyzed as an ancillary aspect of the study. Locations where these sand samples were collected are shown in Figure 2-3. The results of the sand analysis are summarized in Table 3-2. As shown in Table 3-2,

TABLE 3-1

DISTRIBUTION AND RELATIVE DENSITIES
OF MONITORED PLANT TAXA

Species	Density Rating Number[1] 1	2	3	4	Total Quadrats[2] Of Occurrence
Ammobroma sonorae	63	24	10	4	101
Eriogonum deserticola	111	332	91	10	544
Croton wigginsii	67	83	40	1	191
Astragalus magdalenae var. *peirsonii*	62	69	15	1	147
Astragalus lentiginosus var. *borregauus*	6	15	5	0	26
Palafoxia arida var. *gigantea*	72	91	13	0	176
Helianthus niveus ssp. *tephrodes*	121	122	14	0	257

[1] Refer to Tables 2-2 and 2-3 in Section 2 for definition of rating numbers.

[2] Total numbers of quadrants in which plants were found out of a total of 1,481 quadrants.

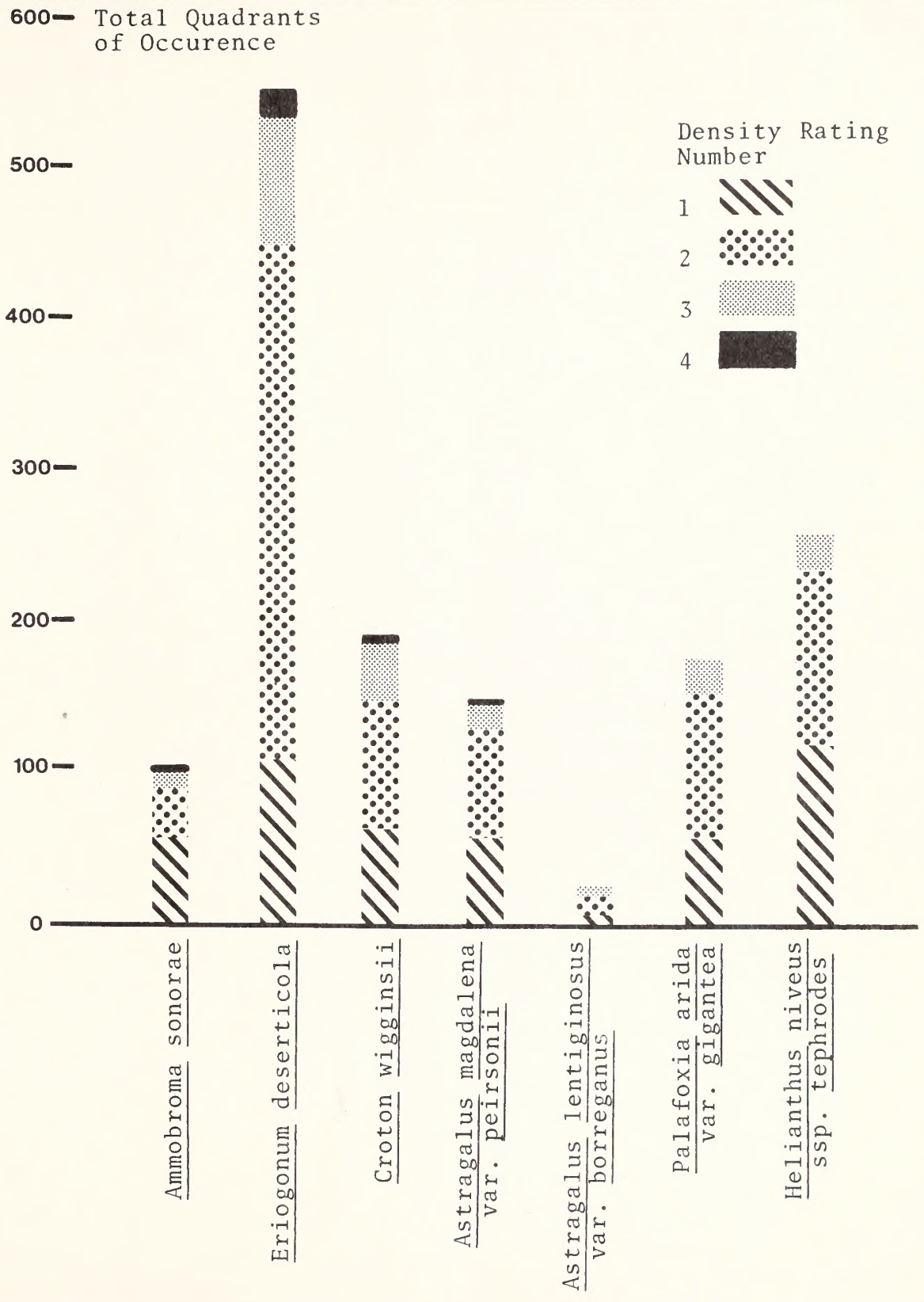
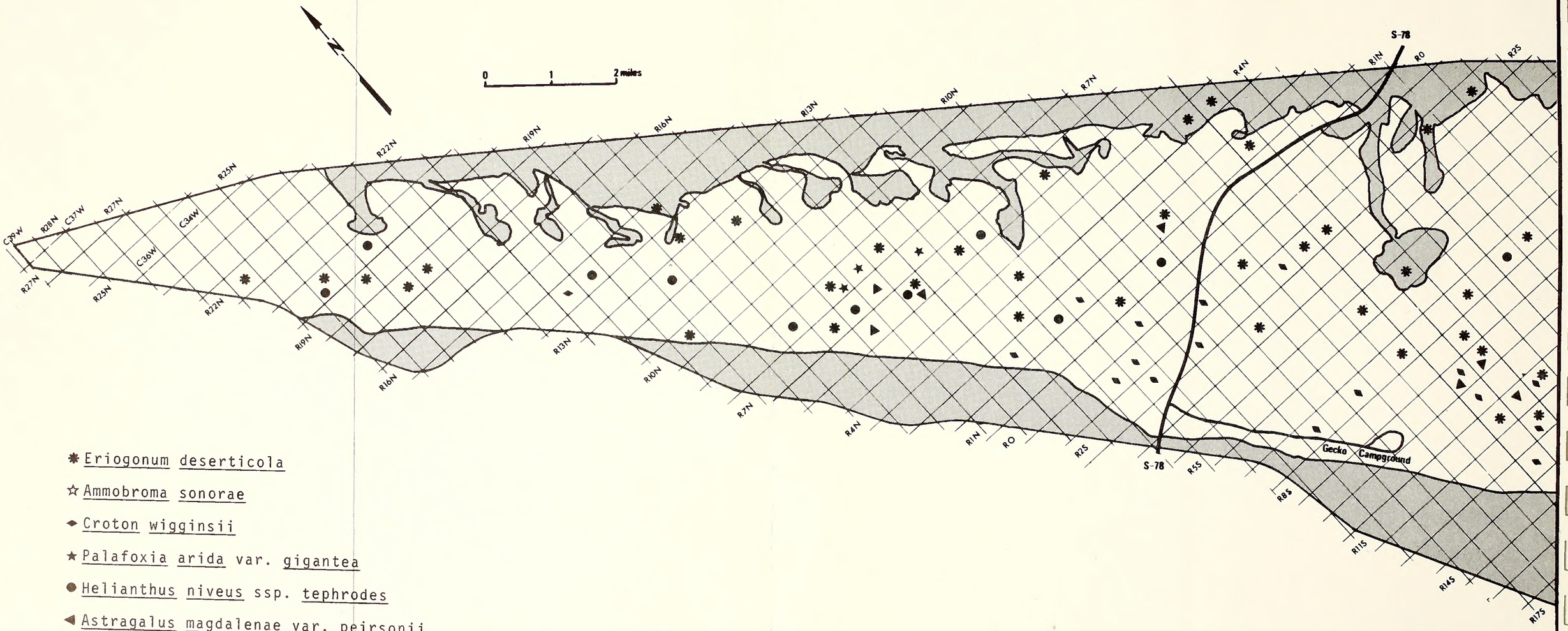


FIGURE 3-15

Distribution and Relative Densities of Sensitive Species



✱ Eriogonum deserticola

☆ Ammobroma sonorae

◆ Croton wigginsii

★ Palafoxia arida var. gigantea

● Helianthus niveus ssp. tephrodes

◀ Astragalus magdalenae var. peirsonii

□ Astragalus lentiginosus var. borreganus

FIGURE 3-16 **Distribution of Sensitive Species**

Southern Pacific Railroad

R5S R8S R11S R14S R17S R20S R22S R26S S-34 R29S R32S R35S I-8 R38S R41S R42S

C42E C39E C36E C33E C30E C27E C24E C21E C18E C15E C12E C9E C6E C3E C0 C2W

R20S R23S R26S R29S R32S R35S R38S R41S R44S C17E C18E I-8

All American Canal

Coachella Canal

WESTEC Services, Inc.

the sand on the western portion of the dunes appeared to contain larger sand grains than on the eastern dune area. This may be due to the direction of sand-driving winds which blow from the northwest. These data appear to conform with results of previous extensive sand sampling by Norris and Norris, (1961). Samples Number 1 and 4 where taken from areas of extensive Ammobroma coverage. Both of these samples show that sand grains were of a moderately small size.

TABLE 3-2

SOIL ANALYSIS (percent retained by screen)

Mesh Size (1)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
16	0	23.2	0	0	0	0
32	0.4	20.6	2.5	4.2	2.4	86.1
60	58.4	19.9	57.7	45.0	59.2	2.5
115	35.6	27.9	33.7	46.6	34.3	4.6
Bottom Receptical	5.6	8.4	6.1	4.1	4.0	6.8

(1) Number of holes per square inch.

3.4 Wildlife Observed Incidental to the Vegetation Survey

The Algodones Dunes contain a high diversity of vertebrates. Appendix D contains the list of wildlife observed in the Algodones Dunes during the vegetation survey.

3.5 General Field Observations

The Algodones Sand Dunes are commonly perceived as an undulating mass of sand, constantly changing shape. This is only true in part and even then only to a small degree. Navigation over the dunes by helicopter was possible through the identification of prominent depressions, hills, and ridges still coinciding with those features mapped by the USGS in 1948 from aerial photographs. These observations appear to agree with conclusions of Norris and Norris (1961).

Locally, however, it appears that dunes are advancing at a rate of about 10cm/year. This estimate is based on the relationships of plants being engulfed by the advancing slopes.

SECTION 4.0

DISCUSSION

4.1 Plant Associations and Distribution

4.1.1 Species Rarity

The most striking vegetative aspect found within the dunes was the floristic composition of the Dune Psammophytic Scrub vegetation. This association is rare in that the species composition of this association occurs only on the Algodones Dunes. Most species in this association are also of limited range. In fact, a point could be made that this vegetation association is of more limited distribution than the species which compose it.

An interesting discovery during the survey was that the common Ephedra in the dunes was E. trifurca, a species which Jaeger (1941) said was seldom found in California deserts. The distribution is better developed in southeastern Arizona according to Hastings et al. (1972).

One interesting aspect about rare plant species is their abundant occurrence in only a few localities. It is only through regional studies of this type that a proper understanding of the population dynamics of rare and sensitive plant species can be understood.

4.1.2 Evolution and Adaption of the Flora

The similar adaptation of many dune species to mobile deep sand does not appear to be a random coincidence. The relatively young age of the Colorado Desert (approximately 10,000 years before present) and the younger Algodones Dunes (late-Pleistocene) in light of the specific adaptation of psammophytic plants points out the relatively short time required for selection of these specially adapted features.

On a broad evolutionary scale, the relic endemics of Stebbins and Mayor (1965) are common in the flora. These include Hesperocallis undulata, Lyrocarpa coulteri, Olneya tesota, Fagonia pachyacantha, Larrea tridentata, Fouquieria splendens, Oligomeris linifolia, Ammobroma sonorae, Chilopsis linearis, Brandegea begelovii, Geraea canescens, Hymenoclea salsola, and Atrichoseris platyphylla. In a geographic sense, the flora contains several endemics in the more usual traditional manner such as Croton wigginsii and Eriogonum deserticola. One reason for the great number of endemics, relict and geographic, may be suggested by the persistence of desert vegetation even during the height of the Wisconsin glaciation (Martin and Mehringer, 1965).

The convergent evolution of dune-adaptive features found with many of the endemic plants was a very interesting aspect of the survey. The local movement of sand has apparently served as a selective mechanism in the evolution of

the unusually long, singular stems of Croton wigginsii, Helianthus niveus ssp. tephrodes, Astragalus magdalenae var. peirsonii and Ammobroma sonorae with the development of the elongate stem occurring shortly after germination. Barneby (1964) noted the ability of Astragalus magdalenae var. peirsonii to establish itself high on the leeward side of a swelling dune. He speculated that the large seed size of the Astragalus may have been responsible for this feat. The long stem and associated root structure of these perennial endemics apparently allow the plants to reach the moist sand zone soon after germination.

The numerous seedlings of Helianthus niveus ssp. tephrodes, Croton wigginsii, Eriogonum deserticola, and Astragalus magdalenae var. peirsonii were another interesting observation in that it demonstrated the apparent dependence of perennial dune species on the erratic tropical storms from the Gulf of California, rather than upon the normally low winter precipitation. Barneby (1964) noted this cyclic dependence in his observations on Astragalus madgalenae var. peirsonii. Occasionally convection storms originating in Arizona or Sonora may reach as far west as the Algodones Dunes (Odening, 1967), but to what degree these generally attenuated storms affect germination or water availability to dune plants is not known.

4.1.3 Species Distribution and Reproduction

The difference in floristic diversity of Creosote Bush Scrub on the east and west sides of the dunes was apparent. A major factor affecting the difference in diversity may be the additional moisture available to east-side vegetation from runoff from the Chocolate and Cargo Muchacho Mountains. The microtopographic relief on the east side also offers greater habitat diversity. Conversely, more persistent moisture, apparently from seepage from the Coachella Canal, has produced lush stands of almost pure Creosote Bush on the west. This situation may be changed due to a proposed major realignment and lining of the Coachella Canal.

Distribution of psammophytic species within the dune system poses interesting questions.most notably the occurrence of some species, such as Croton wigginsii, primarily on the western portion of the dunes. The apparent decreases in sand grain size from west to east coupled with possible moisture differences may account for some of these patterns of distribution. (Refer to Table 3-2).

Reproduction of Ammobroma sonorae within the dune system is a complex question. The mechanism that the Ammobroma sonorae seed uses to reach the roots of its plant host has never been fully demonstrated. Cothrun (1969) speculates that sand driving winds are responsible for burying the seeds from three to five feet below the sand surface or exposing roots at the surface, enabling Ammobroma seedlings

to attach quickly to the roots of the host plant. These phenomena no doubt occasionally occur; however, field observations indicate that many populations of Ammobroma were located in sheltered areas where such radical shifts in sand would rarely, if ever, occur. An alternative method of seed dispersal may be the deposition of Ammobroma inflorescence fragments and seeds into burrows by Kangaroo Rats. This hypothesis seems plausible due to high Kangaroo Rat activity in the vicinity of dense Ammobroma populations.

Another striking biological phenomenon shown by a component of the Dune Psammophytic Scrub is the amphitropic distribution of Panicum urvilleanum. This sand-binding grass is similar in aspect to the Ammophila arenaria of coastal dune systems and is conspicuous in the Algodones Dunes due to its lush green appearance. Aside from its limited distribution in sandy areas of the Colorado Desert and southern Mojave Desert (Hitchcock and Chase, 1910), the species is widespread in Chile and Argentina where related species occur (Raven 1963).

4.2 Impact of ORV Use

Adverse impacts of ORV use on the desert ecosystem have been the topic of many recent papers. Impact of intensive ORV use on the fauna of the Colorado and Mojave Deserts were identified in studies by Bury, et al. (in press), Bondello (1976) and Busack and Bury (1974). Davidson and Fox (1974)

and Luckenbach (1975) have documented the loss of vegetation from ORV use. These studies focus primarily upon impacts within the desert itself, not upon dune vegetation.

Observation of the result of vehicular activity on and adjacent to the Algodones Dunes was made from the aerial vantage point of the helicopter and through ground surveys. Four-wheel drive activity was significant in some of the Scrub and Woodland areas adjacent to the dune area. This activity, although apparently not intensive because of the danger of vehicle tire puncture,would have essentially the same impacts as identified in the ORV impact studies on the desert habitat. ORV activity in these Scrub areas would be significant because of the high concentrations of Eriogonum deserticola as well as the essential habitat of Astragalus lentiginosus var. borreganus.

Impacts of use of vehicles on the dune areas is a matter of debate. Studies of ORV impacts on sand dunes have been sparse, as Henry (in press) was the only paper found that systematically assessed the impact of ORV use in dunes of the southwest. Dune-adapted vehicles have been observed to cause physical damage to plants they drive over. This damage was usually minor with one or two passes apparently not normally doing permanent harm to the plants. A far more subtle effect may be the compaction of sand by ORV use. The Committee on Environment and Public Policy (1977) and more specifically Liddle and Moore (1974) have shown that sand dune tracks cause compaction of the soil and modification,

including changes in bulk density, water content, and changes in microclimate, particularly thermal changes.

Intensity of ORV use in the dunes appears to be a key factor in impacting dune vegetation. The greatest impact to vegetation occurred within areas of heaviest use. Popular names of these areas in the Algodones Dunes include Competition Hill, the Sluff, Ernie's Hole, Buttercup Valley and Mammoth Wash (See Figure 1-3). The periphery of Gecko Campground and Osborn County Park plus areas contiguous to several unimproved roads were also subjected to heavy use. These unimproved roads occur along Highway 78, the road to Gecko Campground, and south of Interstate 8. The Mammoth Wash Corridor leading from Highway 78 was also in the high impact category. The Gecko Campground Road and the Northern Corridor road pass through a large portion of the essential habitat of Croton wigginsii.

A second, lower level of impact occurred to some degree generally throughout the dunes. The impact was sporadic and appeared to decrease in a noticeable manner away from centers of ORV activity. This was due to the apparent tendency of ORV users to concentrate closer to the paved roads to minimize the hazard of breakdown far from assistance. The more impacted areas of this level showed broken limbs of dune endemics and in several instances shattered plants. The intensity of ORV use that produces the low to moderate

impacts is open to question.

Seedlings were generally abundant in the dune system. None were observed, however, in the high impact areas. Occasionally, seedlings of Croton wigginsii were observed in the less impacted zone of the slope area west of the Gecko Campground road.

It should be noted that despite the observed impacts of ORV use in the Algodones Dunes, healthy reproducing populations of all seven species surveyed occurred within the dunes. The areas away from major ORV activities, notably in the central dune area between Highway 78 and Interstate 8, appeared relatively undisturbed.

SECTION 5.0

ACKNOWLEDGEMENTS

We wish to thank Mr. John Hall, Ms. Maureen Hales and Mr. David Krouskop of the Bureau of Land Management for their cooperation throughout the study. In addition, we appreciate the efforts of Dr. Hyrum Johnson of the Bureau of Land Management for the loan of aerial photographs and Dr. Kristin Berry of the Bureau of Land Management for the loan of material on ORV Impacts. Special thanks should be given to Mr. Walter Sutton, Mr. Jeffery Mamer, and Mr. Michael Butler for their able driving of the field vehicles.

Searches in various herbaria across the nation were aided by Eileen K. Schofield (NY), James White (US), Alice Howard (UC-Jeps), Norton Miller (GH), Marshall Crosby (MO), Elinor Lehto (ASU), Robert Thorne, and Bruce Tucker (RSA-POM).

Several monographers were helpful with data on their studies groups. These were James Reveal, Rupert Barneby, and Billie Turner. Also David Cothrun and Walter Odening provided amplification on their thesis topics.

The prior work on rare plant distributions in California by the California Native Plant Society also served as an important data source of distributional records. During the preparation of the CNPS data, David Verity supplied much of the locality information for the Algodones Dunes.

SECTION 6.0

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APPENDIX A

PROJECT ORGANIZATION

APPENDIX A

PROJECT ORGANIZATION

David A. Parkinson, P.E.	President
William R. Eldredge	Executive Vice President
Michael W. Wright	Regional Manager
John F. Westermeier, M.A., Biology	Project Manager/Team Leader
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Mamer's Welding Service	Field Vehicles

APPENDIX B

ANNOTATED FLORAL CHECKLIST
OF THE ALGODONES DUNES STUDY AREA

Annotated Floral Checklist

of the Algodones Dunes Study Area

Amaranthaceae

Amaranthus palmeri S. Wats. CBS

This species was infrequent in the drainage sinks on the east side of the north and central dunes sectors. The plants were large, apparently due to the large volume of runoff from the past fall.

Tidestromia oblongifolia (S. Wats.) Standl. CBS

Occasional in disturbed areas of Scrub, especially along the railroad embankment.

Asclepiadaceae

Asclepias subulata Dcne. in A. DC. DPS,DMW,CBS

Infrequent in wash areas of Scrub and Woodland but rare in sink areas or other stabilized situations of the dunes themselves.

Asteraceae

Ambrosia dumosa (Gray) Payne. CBS

A common constituent of the Scrub on both flanks of the dunes.

Aster spinosus Benth. CAN

Common on the banks of the canals.

* Denotes non-native taxa.

Atrichoseris platyphylla Gray. CBS

A specimen tentatively identified as this species was collected in a wash area on the east flank of the northern sector.

Baileya pleniradiata Harv. & Gray. CBS,DMW

Common in Scrub and wash areas, particularly on the eastern flank.

Conyza canadensis (L.) Cronq. CAN

Occasional along the canal banks.

Conyza coulteri Gray. DMW

Infrequent in dried sink areas of Woodland on east side of northern sector.

Dicoria canescens T. & G. ssp. canescens DPS,CBS

Abundant in Scrub and dune areas.

Dicoria canescens T. & G. ssp. clarkae (Kenn.) Keck DPS

Occasional in dune areas.

Eclipta alba* (L.) Hassk. CAN

Frequent along canal banks.

Encelia farinosa Gray. ex Torr. CBS

Common on Scrub flats.

Encelia frutescens Gray. CBS

Known from a single collection along a dry wash west of Pilots Knob.

Geraea canescens T. & G. CBS

Known from a single collection on the east side of the central sector.

Helianthus annuus L. ssp. lenticularis (Dougl.)Ckll. CAN

Infrequent along canal banks.

Helianthus niveus (Benth.) Bdg. DPS

ssp. tephrodes (Gray) Heiser.

Frequent in active dune areas.

Heterotheca subaxillaris (Lam.)Britt. & Rose. CBS

Uncommon in dried sinks in the east side of the northern sector.

Hymenoclea salsola T. & G. var. salsola CBS,DMW

Common along washes and in open areas of Scrub.

Lactuca serriola* L. CAN

Occasional along canal banks.

Palafoxia arida Turner & Morris var. arida CBS,DPS

Frequent in dune system.

Palafoxia arida T. & M. DPS

var. gigantea (Jones) T. & M.

Frequent in dune system.

Pectis papposa Harv. & Gray ex Gray. CBS

Occasional in open areas of east side.

Perityle emoryi Torr. in Emory. CBS

Known from a single collection from a wash area in the east side of the northern sector.

Pluchea sericea (Nutt.) Cov. CAN

Occasional along canal banks.

Psathyrotes ramosissima (Torr.) Grav. CBS

Uncommon in wash area in Scrub on east side of northern sector.

Rafinesquia californica Nutt. CBS

Uncommon in wash areas of Scrub on east side.

Sonchus oleraceus* L. CBS

Uncommon in dried sink areas on east side.

Stephanomeria pauciflora (Torr.) A. Nels. CBS

Frequent in Scrub areas on east side.

Bignoniaceae

Chilopsis linearis (Cav.) Sweet. DMW,DPS,CBS

A common constituent of the Woodland and occasionally persisting in invading dunes.

Boraginaceae

Amsinckia tessellata Gray. CBS

A single collection from a wash area on the east flank of the northern dune sector.

Coldenia palmeri Gray. CBS

Occasional in open areas of Scrub on both flanks of the dunes.

Coldenia plicata (Torr.) Cov. DPS,CBS

Common on stable, usually windward slopes of the dunes.

Cryptantha angustifolia (Torr.) Greene. CBS

Occasional in open areas of Scrub.

Cryptantha barbigera (Gray) Greene. CBS

Occasional in open areas of Scrub.

Cryptantha costata Bdg. CBS

Known from a single collection from the Scrub area east of the northern sector.

Heliotropium curassavicum L. var. oculatum (Heller)Jtn. CBS

Infrequent in alkaline areas of washes on east side.

Brassicaceae

Lepidium lasiocarpum Nutt. CBS

Infrequent in open Scrub areas of the east side.

Lyrocarpa coulteri Hook. & Harv. var. palmeri CBS
(S. Wats.) Roll.

A depauperate specimen tentatively identified as this taxon was taken in a wash area on the east side of the northern sector.

Sisymbrium altissimum* L. CBS

Frequent in open and disturbed areas of Scrub.

Cactaceae

Opuntia acanthocarpa Engelm. & Bigel. CBS
var. coloradensis L. Benson.

Uncommon in open Scrub areas on east side of central sector.

Opuntia basilaris Engelm. & Bigel. var. basilaris CBS

Occasional in open areas of east side.

Opuntia ramosissima Engelm. CBS

Infrequent in open areas of east side.

Chenopodiaceae

Atriplex elegans (Moq.) D. Dietr. ssp. fasciculata CBS
(S. Wats.) Hall & Clem.

Infrequent in washes and alakline areas on the east side of the northern sector.

Chenopodium murale* L. CAN

An infrequent weed along the canal roads.

Cucurbitaceae

Brandegea bigelovii (S. Wats.) Cogn. CBS,DMW

Occasional in washes and in shaded areas about larger shrubs and trees, particularly on the eastern flank.

Cucurbita palmata S. Wats. DMW,CBS

Infrequent in washes and disturbed areas.

Ephedraceae

Ephedra trifurca Torr. DPS,CBS

Occasional in dune areas and about sinks and common in Scrub on west side.

Euphorbiaceae

Croton wigginsii Wheeler. DPS,CBS

Common on western half of dune system and infrequent in wash areas on east side.

Ditaxis neomexicana (Muell.-Arg.) Heller. CBS

Infrequent in open areas of Scrub on east side.

Ditaxis serrata (Torr.) Heller. CBS

Occasional in open areas of Scrub on east side.

Euphorbia parishii Greene. CBS

Known from a single collection in Scrub on the east side of the northern sector.

Euphorbia polycarpa Benth. var. polycarpa CBS

Common on Scrub flats.

Stillingia linearifolia S. Wats. CBS,DMW

Occasional in washes and open areas of Scrub and Woodland on east side.

Stillingia spinulosa Torr. in Emory. CBS

Infrequent in open Scrub areas on east side.

Fabaceae

Astragalus lentiginosus Dougl. var. borreganus Jones. DPS,CBS

Uncommon in small sink areas on the east flank of the dunes in areas transitional between dunes and Scrub vegetation. Much of the growth of the populations appeared to be in response to the large amount of precipitation received last fall.

Astragalus magdalenae Greene var. peirsonii (Munz & McBurney) Barneby. DPS

Frequent but restricted to windward faces of dunes, particularly about the central portion of the system.

Cercidium floridum Benth. DMW

A common and conspicuous element of the Woodland.

Dalea emoryi Gray. CBS

Occasional in washes and open areas of Scrub and sinks.

Dalea mollis Benth. CBS

Uncommon in open areas of Scrub on east side and sinks.

Dalea spinosa Gray. CBS,DMW

Occasional in washes, especially near the railroad tracks.

Melilotus albus* Desr. CAN

Occasional on canal banks.

Olneya tesota Gray. DMW

Common constituent of the Woodland, mainly on the east side.

Prosopis glandulosa Torr. var. torreyana (Benson) M.C. Jtn. DMW

Common constituent of the Woodland and infrequent in large sinks of the dune system.

Prosopis pubescens Benth. DMW,CBS

Infrequent in Woodland and Scrub areas on east side.

Fouquieriaceae

Fouquiera splendens Engelm. CBS

Uncommon in open Scrub of the east side.

Haloragaceae

Myriophyllum exalbescens Fern. CAN

Common along canal banks and as flotsam.

Hydrophyllaceae

Nama hispidum Gray var. revolutum Jeps. CBS

Infrequent along washes on the east side.

Phacelia crenulata Torr. var. crenulata CBS

Known from a single collection in Scrub on the east side of the northern sector.

Krameriaceae

Krameria grayi Rose & Painter. CBS

Infrequent in open areas of Scrub on east side.

Lennoaceae

Ammobroma sonorae Torr. ex Gray. DPS

Occasional on the more stable, windward face of dunes and uncommon in the Scrub west of the dunes.

Liliaceae

Hesperocallis undulata Gray. DPS,CBS

Infrequent in dune areas, particularly adjacent to sinks or very stable sand areas. Apparently more common than revealed by persisting dead material.

Loasaceae

Petalonyx thurberi Gray ssp. thurberi DPS

Common in dune system.

Mentzelia longiloba Darl. CBS,DMW

Frequent along washes and in open areas of Scrub on the east side.

Malvaceae

Eremalche rotundifolia (Gray) Greene. CBS

Known from a herbarium voucher taken north of Interstate 8 on the east flank.

Sphaeralcea emoryi Torr. in Gray ssp. arida Kearn. CBS,DMW

Uncommon in washes on east side.

Sphaerlacea orcuttii Rose. CBS,DMW

Abundant in sink areas on east side.

Nyctaginaceae

Abronia villosa S. Wats. var. villosa DPS

Two collections were made of this taxon, one in the middle of the south-central portion of the dunes and another north of Highway 78, adjacent to Osborn Park.

Onagraceae

Camissonia arenaria (A. Nels.) Raven. CBS

A depauperate specimen taken on the east side of the northern sector is tentatively identified as this species.

Camissonia boothii (Dougl. in Hook.) Raven ssp. condensata (Munz) Raven. CBS

Uncommon in open areas of Scrub on the eastern flank.

Camissonia cardiophylla (Torr.) Raven ssp. cardiophylla CBS

Infrequent in Scrub or open sink areas of the dunes.

Camissonia claviformis (Torr. & Frem.) Raven ssp. yumae (Raven) Raven. CBS,DPS

Occasional in open scrub areas or small sinks on the eastern periphery of the dunes.

Oenothera deltoides Torr. & Frem. DPS,CBS

Abundant on stable dune slopes and in Scrub.

Orobanchaceae

Orobanche cooperi (Gray) Heller. CBS

Occasional in open areas on east side.

Papaveraceae

Argemone munita Dur. & Hilg. ssp. argentea G. Owenby. CBS

Uncommon in Scrub on the east flank of the northern sector.

Plantaginaceae

Plantago insularis Eastw. var. fastigiata (Morris)Jeps. CBS

Common in open Scrub areas.

Plantago purshii R. & S. var. oblonga (Morris) Shinner. CBS

Occasional in open Scrub areas.

Poaceae

Aristida adscensionis L. CBS

Occasional in open or distrubed areas of Scrub.

Aristida californica Thurb. CBS

Common in otherwise open spots in the Scrub.

Arundo donax* L. CAN

Frequent along most of the canals.

Avena fatua* L. CAN

Occasional along the canal banks.

Bouteloua barbata Lag. CBS

A single collection of this species was made on the east flank of the northern sector in Scrub area.

Cynodon dactylon (L.) Pers. CAN

Frequent along the canal banks.

Echinochloa crus-pavonis (HBK.) Schult. var. crus-pavonis CAN

Uncommon along canal patrol road.

Hilaria rigida (Thurb.) Benth. ex Scribn. CBS,DMW

Common along washes in Scrub areas.

Lolium perenne* L. ssp. perenne CAN

Infrequent along canal banks.

Panicum urvilleanum Kunth. DPS

Common in dune system.

Schismus barbatus* (L.) Thell. CBS

Common in open Scrub areas.

Polemoniaceae

Langloisia schottii (Torr.) Greene. DPS

Known from a single collection near a sink in the south-central sector of the dunes.

Polygonaceae

Chorizanthe brevicornu Torr. ssp. brevicornu CBS

Known from a single collection in Scrub on the eastern flank of the northern sector.

Chorizanthe corrugata (Torr.) T. & G. CBS

Known from a single collection in Scrub on the eastern flank of the northern sector.

Chorizanthe rigida (Torr.) T. & G. CBS

Occasional on otherwise bare flats on the east side and in the large sinks of the south-central dune area.

Eriogonum deflexum Torr. ssp. deflexum CBS

Known from a single collection from a wash on the east side of the northern sector.

Eriogonum deserticola S. Wats. DPS,DMW,CBS

Abundant in dunes and especially so in wash areas on the east side.

Eriogonum inflatum Torr. & Frem. var. deflatum Jtn. CBS

Known from a single collection from the east side of the northern sector.

Eriogonum thomasii Torr. CBS

Known from a single collection in Scrub on the east side of the northern sector.

Polygonum fusiforme Greene. CAN

Frequent along canals.

Potamogentonaceae

Potamogeton pectinatus L. CAN

Occasional along canals and as flotsam.

Resedaceae

Oligomeris linifolia (Vahl) Macbr. CBS

Frequent in open areas of Scrub.

Solanaceae

Datura discolor Bernh. CBS,DMW

Common in washes and open areas.

Tamaricaceae

Tamarix aphylla* (L.) Karsten. CBS,DMW

Uncommon in washes in Scrub area east of northern sector. Apparently seeding from trees planted along railroad tracks between Amos and Tortuga.

Viscaceae

Phoradendron californicum Nutt. CBS,DMW

Occasional in Woodland on east side.

Zygophyllaceae

Fagonia pachyacantha Rydb. in Vail & Rydb. CBS

Known from a single collection on the east side of the central sector.

Larrea tridentata (Sesse & Moc. ex DC.) Cov. CBS

Common on both sides of the dune system.

Key to Abbreviation:

CBS - Creosote Bush Scrub
DMW - Desert Microphyll Woodland
DPS - Desert Psammophytic Scrub
CAN - Canal

APPENDIX C

LINE INTERCEPT VEGETATION ANALYSIS RESULTS

LINE INTERCEPT VEGETATION ANALYSIS RESULTS

The following tables summarize the results of line intercept vegetation analysis for the Creosote Bush Scrub, Desert Microphyll Woodland, Desert Psammophytic Scrub and a transition area between Desert Psammophytic Scrub and Desert Microphyll Woodland. All computations were made as described in Cox (1976). Location of transect locations are shown in Figure 2-2 within the text.

Table C-1

NUMERICAL DOMINANCE - CREOSOTE BUSH SCRUB

	Transect Number							
Species	3	4	5	6	8	13	14	17
Ambrosia dumosa				4.16	4.5		5.16	
Larrea tridentata	13.66	30.5	44.12	28.21	42.5	20.5	16.75	42
Aristida californica	0.8		0.88	10.21			0.5	
Caryophyll				0.88		8.5		
Ephedra trifurca		7.5		12.25				
Baileya pleniradiata				.414			0.33	
Oenothera deltoides		1	6.29	1.3			0.42	
Palafoxia arida var. *arida*	1.25		0.5	1.37			0.75	0.5
Dalea mollis				1.08			0.5	
Camissonia claviformis			3.38	1.29				
Euphorbia polycarpa				0.3				
Plantago insularis	6.5		5.65				11.6	
Composite			1.66					
Cryptantha augustiflora			0.5					
Dalea emoryi						3		

Table C-2

RELATIVE DOMINANCE - CREOSOTE BUSH SCRUB

	Transect Number							
Species	3	4	5	6	8	13	14	17
Ambrosia dumosa				6.83	9.55		14.33	
Larrea tridentata	63.56	78.21	70.11	46.27	90.45	64.06	46.51	98.08
Aristida californica	0.37		1.33	16.74			1.39	
Caryophyll				1.44				
Ephedra trifurca		19.23		20.09		26.56		
Baileya pleniradiata				0.68			0.92	
Oenothera deltoides		2.56	9.99	2.13			1.17	
Palafoxia arida var *arida*	5.82		0.79	2.26			2.08	1.92
Dalea mollis				1.77			1.39	
Camissonia claviformis			5.36	1.30				
Euphorbia polycarpa				0.49				
Plantago insularis	30.25		8.98				32.31	
Composite			2.65					
Cryptantha augustiflora			0.79					
Dalea emoryi						9.38		

Table C-3

FREQUENCY - CREOSOTE BUSH SCRUB

Species	Transect Number 3	4	5	6	8	13	14	17
Ambrosia dumosa				7.5	9.5		6	
Larrea tridentata	19	32	32.5	28.5	47.0	22.5	45	51
Aristida californa	1		5.0	25.5			4	
Caryophyll				1.5				
Ephedra trifurca		8.5		12.5		9		
Baileya pleniradiata				1			2	
Oenothera deltoides		2.5	3.5	3			3	
Palafoxia arida var *arida*	1		1.0	2.5			2	1.0
Dalea mollis				3.5				
Camissonia claviformis			8.0	1.5				
Euphorbia polycarpa				1				
Plantago insularis	23		41.5				52	
Composite			6.0					
Cryptantha augustiflora			2.0					
Dalea emoryi						3.5		

Table C-4

RELATIVE FREQUENCY - CREOSOTE BUSH SCRUB

Species	Transect Number 3	4	5	6	8	13	14	17
Ambrosia dumosa				8.62	16.81		5.17	
Larrea tridentata	43.18	74.42	43.93	32.39	83.19	64.29	38.79	98.08
Aristida californica	2.27		4.18	28.98			3.45	
Caryophyll				1.7				
Ephedra trifurca				14.20		25.71		
Baileya pleniradiata				1.14			1.72	
Oenothera deltoides		5.81	2.93	3.41			2.59	
Palafoxia arida var *arida*	2.27		0.84	2.84			1.72	1.92
Dalea mollis				3.98			1.72	
Camissonia claviformis			6.69	1.70				
Euphorbia polycarpa		19.77		1.14				
Plantago insularis	52.27		34.73				44.83	
Composite			5.02					
Cryptantha augustiflora			1.67					
Dalea emoryi						10.00		

Table C-5

NUMERICAL DOMINANCE - DESERT PSAMMOPHYTIC SCRUB

	Transect Number									
Species	9	10	11	12	15	16	17	19	20	21
Croton wigginsii		26	8.0	10.5	6.75	2.25	5.75		3.12	
Eriogonum deserticola	11.75		10.0	14.0	3.5		1.25	5.25	3.25	9.0
Camissonia claviformis	5.0									0.75
Palafoxia arida var *gigantea*	1.5		3.75					5.0	1.00	1.0
Dicoria canescens			4.0	0.25	3.5	4.5			2.75	0.5
Helianthus niveus ssp *tephrodes*					2.0			3.25	0.25	
Petalonyx thurberi	2.5							4.25	1.25	
Oenthera deltoides			1.9					8.75		
Ammobroma sonorae			0.05					0.75		
Ephedra trifurca				3.25						
Cryptantha augustifolia			0.4							
Asclepias subulata			2.5							
Dalea emoryi			2.0							

Table C-6

RELATIVE DOMINANCE - DESERT PSAMMOPHYTIC SCRUB

	Transect Number									
Species	9	10	11	12	15	16	17	19	20	21
Croton wigginsii		100	24.54	37.5	42.6	33.33	82.14		26.88	
Eriogonum deserticola	56.63		30.67	50.00	22.22		17.86	26.25	27.96	80.00
Camissonia claviformia	24.10									6.67
Palafoxia arida var *gigantea*	7.23		11.5					25.0	8.6	8.89
Dicoria canescens			12.27	0.89	22.22	66.67			23.66	4.44
Helianthus niveus ssp *tephrodes*					12.7			16.25	2.15	
Petalonyx thurberi	12.5							20.00	10.75	
Oenothera deltoides			5.83					8.75		
Ammobroma sonorae			0.15					3.75		
Ephedra trifurca				11.61						
Cryptantha augustifolia			1.23							
Asclepias subulata			7.67							
Dalea emoryi			6.13							

Table C-7

FREQUENCY - DESERT PSAMMOPHYTIC SCRUB

	Transect Number									
Species	9	10	11	12	15	16	17	19	20	21
Croton wigginsii		100	8.5	11.5	8.0	2.5	9.0		3.75	
Eriogonum deserticola	13.0		6.5	16.5	4.5		2.0	6.0	3.75	11.5
Camissonia claviformis	7.0									2.0
Palafoxia arida var *gigantea*	2.0		6.0					6.0	1.25	2.0
Dicoria canescens			4.5	0.5	4.0	5.0			2.25	1.0
Helianthus niveus ssp *tephrodes*					3.0			4.5	0.5	
Petalonyx thurberi	3.0							5.5	1.5	
Oenothera deltoides			2.0					3.0		
Ammobroma sonorae			0.5					1.5		
Ephedra trifurca				4.2						
Cryptantha augustifolia			0.5							
Asclepias subulata			3.0							
Dalea emoryi			2.5							

Table C-8

RELATIVE FREQUENCY - DESERT PSAMMOPHYTIC SCRUB

	Transect Number									
Species	9	10	11	12	15	16	17	19	20	21
Croton wigginsii		100	25.00	35.38	41.03	33.33	81.82		28.85	
Eriogonum deserticola	52.00		19.12	50.77	23.08		18.18	22.64	28.85	69.7
Camissonia claviformis	28.00								17.31	12.12
Palafoxia arida var *gigantea*	8.00		17.65					22.64	9.62	12.12
Dicoria canescens			13.24	1.54	20.51	66.67				6.06
Helianthus niveus ssp *tephrodes*					15.38			16.98	3.85	
Petalonyx thurberi	12.00							20.75	11.54	
Oenothera deltoides			5.88					11.32		
Ammobroma sonorae			1.47					5.66		
Ephedra trifurca				12.31						
Cryptantha augustifolia			1.47							
Asclepias subulata			8.82							
Dalea emoryi			7.35							

Table C-9

NUMERICAL DOMINANCE - DESERT MICROPHYLL WOODLAND

	Transect Number	
Species	1	2
Dicoria canescens		2.75
Camissionia cardiophylla		4.5
Palafoxia arida var *arida*		6.5
Chilopsis linearis		22.0
Coldenia palmeri		1.75
Cercidium floridum	37	5.5
Cryptantha augustifolia		.3
Stillingea linearifolia		1.75
Baileya pleniradiata		1.25
Sphaeralcea emoryi	26.05	
Brandegea bigelovii	17	
Lepidium lasiocarpum	0.5	
Hilaria rigida	4	
Sisymbrium altissimum	0.5	
Larrea tridentata	41	

Table C-10

RELATIVE DOMINANCE - DESERT MICROPHYLL WOODLAND

Species	Transect Number 1	2
Dicoria canescens		5.94
Camissonia cardiophylla		9.72
Palafoxia arida var *arida*		14.04
Chilopsis linearis		47.52
Coldenia palmeri		3.78
Cercidium floridum	29.02	11.88
Cryptantha augustifolia		0.65
Stillingia linearifolia		3.78
Baileya pleniradiata		2.70
Sphaeralcea emoryi	20.00	
Brandegea bigelovii	13.33	
Lepidium lasiocarpum	0.39	
Hilaria rigida	4.57	
Sisymbrium altissimum	0.39	
Larrea tridentata	32.16	

Table C-11

FREQUENCY - DESERT MICROPHILL WOODLAND

Species	Transect Number 1	2
Dicoria canescens		5.0
Camissonia cardiophylla		8.0
Palafoxia arida var *arida*		8.5
Chilopsis linearis		24.5
Coldenia palmeri		2.5
Cercidium floridum	37.5	6.0
Cryptantha augustifolia		0.5
Stillingia linearifolia		2.5
Baileya pleniradiata		2.5
Sphaeralcea emoryi	32.5	
Brandegea bigelovii	20.5	
Lepidium lasiocarpum	1	
Hilaria rigida	2.5	
Sisymbrium altissimum	1	
Larrea tridentata	51	

Table C-12

RELATIVE FREQUENCY - DESERT MICROPHYLL WOODLAND

	Transect Number	
Species	1	2
Dicoria canescens		8.33
Camissonia cardiophylla		13.33
Palafoxia arida var *arida*		14.17
Chilopsis linearis		40.83
Coldenia palmeri		4.17
Cercidium floridum	25.25	10.00
Cryptantha augustifolia		0.83
Stillingia linearifolia		4.17
Baileya pleniradiata		4.17
Sphaeralcea emoryi	21.99	
Brandegea bigelovii	13.8	
Lepidium lasiocarpum	1.0	
Hilaria rigida	1.68	
Sisymbrium altissimum	0.67	
Larrea tridentata	34.34	

Table C-13

LINE INTERCEPT RESULTS FOR TRANSECT 18 - TRANSITION BETWEEN DPS AND PMW

	Dominance	Relative Dominance	Frequency	Relative Frequency
Dicoria canescens	6.75	20.0	14.0	27.45
Palafoxia arida var *arida*	2.25	6.67	3.5	6.86
Camissonia cardiophylla	5.75	19.04	11.0	21.57
Chilopsis linearis	8.00	23.70	8.5	16.67
Cercidium floridum	9.50	28.15	10.0	19.61
Eriogonum deserticola	0.50	1.48	2.0	3.92
Baileya pleniradiata	1.00	2.96	2.0	3.92

TABLE C-14

LINE INTERCEPT RESULTS FOR TRANSECT 7
TRANSITION BETWEEN CBS and DPS

	Dominance	Relative Dominance	Frequency	Relative Frequency
Larrea tridentata	4.25	41.46	5.0	41.67
Ephedra trifurca	1.00	9.75	1.0	8.33
Croton wigginsii	2.00	19.50	2.5	20.83
Eriogonum deserticola	3.00	29.27	3.5	29.17

APPENDIX D

VERTEBRATES OF THE ALGODONES DUNES

APPENDIX D

VERTEBRATES OF THE ALGODONES SAND SUNES

Incidental to the vegetation study of the Algodones Dunes, the field teams observed many wildlife species. The following three tables list the Reptiles, Mammals, and Bird species observed in the dunes.

TABLE D-1

REPTILES OBSERVED BY THE STUDY TEAM

Western Shovel-nosed Snake	Chionactis occipitalis
Sidewinder	Crotalus cerastes
Flat-tailed Horned Lizard	Phrynosoma m'calli
Zebra-tailed Lizard	Callisaurus draconoides
Colorado Desert Fringed-toed Lizard	Uma notata
Long-nosed Leopard Lizard	Crotophytus wislizenii
Desert Iguana	Dipsosaurus dorsalis
Long-tailed Brush Lizard	Urosaurus graciosus

TABLE D-2

MAMMALS OBSERVED BY SURVEY TEAM

Roundtail Ground Squirrel	*Spermophilus tereticaudus*
Antelope Ground Squirrel	*Ammospermophilus leucurus*
Merriam's Kangaroo Rat	*Dipodomys merriami*
Desert Kangaroo Rat	*Dipodomys deserti*
Muskrat	*Ondatra zebethica*
Desert Woodrat	*Neotoma lepida*
Desert Cottontail	*Sylvilagus auduboni*
Jackrabbit	*Lepus californicus*
Coyote	*Canis latrans*
Badger	*Taxidea taxus*
Kit Fox	*Vulpes macrotis*
Mule Deer	*Odocoileus hemionus*

TABLE D-3

BIRDS OBSERVED BY FIELD TEAM

Red-tailed Hawk

Turkey Vulture

Roadrunner

Great-horned Owl

Burrowing Owl

Lesser Nighthawk

Loggerhead Shrike

Black-tailed Gnatcatcher

Phainopepla

Ash-throated Flycatcher

White-winged Dove

LeConte's Thrasher

Cassin's Kingbird

Cliff Swallow

Verdin

Mourning Dove

House Finch

Great Blue Heron

Bushtit

Ladder-backed Woodpecker

APPENDIX E

GLOSSARY

APPENDIX E

GLOSSARY

Amphitropic - Occuring on both sides of the tropics.

Arborescent - Tree-like in nature.

Essential habitat - A habitat or microhabitat which is necessary for a species survival.

Exsiccatae - Dried herbaria specimen or other specimen.

Frequency - Defined as $\frac{\text{Intervals in which species occurs}}{\text{Total number of transect intervals}} \times 100$

Herbarium - A collection of dried plants, mounted and classified. Also, the room or building where the collection is kept.

Hydrophytic - "Water-loving" plants.

Hymenopterous - Belonging to an order of insects which include Bees, Wasps, Ants and Gallflies.

Inflorescences - The flower cluster on a plant.

Legume - A superior one-celled fruit of a simple pistil usually dehiscent into two valves, having the seeds attached along the ventral suture; a leguminous plant.

Microphyll - Small leaves.

Morphological - The form of plants.

Numerical Dominance - Defined as:

$$\frac{\text{Total of intercept lengths for a Species}}{\text{Total transect length}} \times 100$$

Pistillate - Provided with pistil, but not stamens; a female.

Psammophytic - "Sand-loving" plants.

Pubescence - Downy or hairy; covered with soft fine hairs.

Relative Dominance - Defined as:

$$\frac{\text{Total of intercept lengths of a Species}}{\text{Total of intercept lengths for all Species}} \times 100$$

Relative Frequency - Defined as:

$$\frac{\text{Frequency for a Species}}{\text{Total of weighted frequency for all species}} \times 100$$

Stigmas - The receptive part of a pistal on which the pollen germinates.

Taxa - Any classification unit including genera, species, subspecies or varieties.

Type Localities - The location where the type for the species, subspecies or variety was collected.

Voucher Localities - Locations where herbaria specimens have been collected.

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Bldg. 50, Denver Federal Center
Denver, CO 80225

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410 West Main St.
Alhambra, CA 91801

Anaheim Public Library
500 West Broadway
Anaheim, CA 92805

Los Angeles Arboretum
301 N. Baldwin Ave.
Los Angeles, CA 91006

Citrus Community College
18824 East Foothill Blvd.
Azusa, CA 91702

Barstow Library
304 E. Buena Vista
Barstow, CA 92311

Palo Verde Library
125 W. Chanslorway
Blythe, CA 92225

Brawley Public Library
400 Main
Brawley, CA 92227

Brea Branch Library
642 South Brea Blvd.
Brea, CA 92621

Calexico Public Library
420 Heber Ave.
Calexico, CA 92231

Imperial Valley Campus
San Diego State Univ.
720 Heber Ave
Calexico, CA 92231

Chula Vista Public Library
276 Fourth Ave.
Chula Vista, CA 92010

Southwestern College Library
900 Otay Lakes Road
Chula Vista, CA 92010

Rancho Santa Ana Botanic Gdn
1500 N. College Ave.
Claremont, CA 91711

Orange Coast College
2701 Fairview Road
Costa Mesa, CA 92626

El Centro Public Library
539 State St.
El Centro, CA 92243

Escondido Public Library
239 South Kalmia St.
Escondido, CA 92025

Fontana Branch Library
8334 Emerald
Fontana, CA 92335

CSU, Fullerton Library
800 N. State College Blvd.
Fullerton, CA 92634

Fullerton Public Library
353 West Commonwealth Ave.
Fullerton, CA 92632

Glendale Public Library
222 East Harvard St.
Glendale, CA 91205

Golden West College Library
15744 GoldenWest St.
Huntington Beach, CA 92647

Imperial Public Library
200 W. 9th St.
Imperial, CA 92251

Imperial Valley College Librar
Ira Aten Rd & Hwy 111
Imperial, CA 92251

Indio Branch Library
45-430 Fargo
Indio, CA 92201

UC Irvine Library
Irvine
CA 92715

Lakeside County Library
9839 Vine St.
Lakeside, CA 92040

La Mesa Library
8055 University Ave.
La Mesa, CA 92041

CSU, Long Beach Library
6101 E. 7th St
Long Beach, CA 90840

Long Beach Public Library
Ocean & Pacific Ave.
Long Beach, CA 90802

CSU, Los Angeles
John F. Kennedy Mem. Library
5151 State University Drive
Los Angeles, CA 90032

LA County Public Library
320 West Temple St.
Los Angeles, CA 90053

LA Public Library
630 West Fifth Street
Los Angeles, CA 90071

LA Public Library
200 N. Main St., Rm 530
City Hall East
Los Angeles, CA 90012

Occidental College Library
1600 Campus Road
Los Angeles, CA 90041

UCLA Library
405 Hilgard Ave.
Los Angeles, CA 90024

University of So. CA Libr.
University Park
Los Angeles, CA 90007

National City Public Lib.
200 East 12th St
National City, CA 92050

Newport Beach Public Lib.
2005 Dover Dr.
Newport Beach, CA 92660

California State Univ.
Northridge Library
18111 Nordhoff St.
Northridge, CA 91324

Cerritos College Library
11110 E. Alondra Blvd.
Cerritos, CA 90650

Oceanside Public Library
615 Fourth St.
Oceanside, CA 92054

Ontario City Library
215 East "C" St.
Ontario, CA 91764

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Thurmond Clarke Memorial Li
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Orange, CA 92666

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Orange, CA 92668

Orange Co. Public Lib.
431 City Drive South
Orange, CA 92668

Orange Public Library
101 North Center
Orange, CA 92666

Palm Springs Public Lib.
300 South Sunrise
Palm Springs, CA 92262

Pasadena City College Lib.
1570 East Colorado Blvd.
Pasadena, CA 91106

Pasadena Public Library
285 East Walnut St.,
Pasadena, CA 91101

Riverside City & County
Public Library
3581 Seventh St.(P.O.Box 468)
Riverside, CA 92502

University of CA, Riverside
950 University Ave.
Riverside, CA 92507

California State College,
San Bernardino Library
5500 State College Parkway
San Bernardino, CA 92407

San Bernardino County Library
104 W. 4th Street
San Bernardino, CA 92415

San Bernardino Public Library
401 North Arrowhead Ave.,
San Bernardino, CA 92401

California State University,
San Diego
Malcolm Love Library
San Diego, CA 92115

San Diego County Library
5555 Overland Ave.,
San Diego, CA 92123

San Diego Gas & Electric Co.Lib
101 Ash St.,(P.O. Box 1831)
San Diego, CA 92112

San Diego Mesa College Lib.
7250 Mesa college Dr.,
San Diego, CA 92111

San Diego Community Colleges
San Diego City College Library
1425 Russ Blvd.,
San Diego, CA 92101

San Diego Public Library
820 "E" Street
San Diego, CA 92101

San Diego Public Library
Governmental Reference Library
Room 602 County Admin. Center
1600 Pacific Highway
San Diego, CA 92101

San Diego Public Library
Governmental Reference Library
Room 602 County Admin. Center
1600 Pacific Highway
San Diego, CA 92101

University of San Diego
James S. Copley Library
Alcala Park
San Diego, CA 92110

Santa Ana College,Nealley Lib.
17th Street at Bristol
Santa Ana, CA 92706

Santa Ana Public Lib.
P. O. Box 1988
Santa Ana, CA 92702

Tustin Branch Library
13682 Newport Ave.
Tustin, CA 92680

Victorville Branch, S.B. Co.
Library
15011 Circle Dr.,
Victorville, CA 92392

Mt. San Antonio College
Educational Resources Library
1101 N. Grand Ave.,
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18262 Lemon Dr.,
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